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THE PSYCHOLOGICAL REVIEW

SENSUOUS DETERMINANTS OF PSYCHOLOGICAL ATTITUDE[1]

BY H. L. HOLLINGWORTH

Barnard College, Columbia University

A survey of the past discloses numerous precedents for such an occasion as this. There is dignified sanction for being entertaining, or for being dull; for announcing results of high significance, or for elaborating the inconsequential. Another approved alternative seems to be that of airing some personal obsession. It is this precedent that is to be followed tonight, not merely because of its greater ease and comfort, but also because it is a procedure that should occasionally be resurrected.

The speaker freely admits, then, that he is a fanatic, suffering from a delusional system. No doubt any fanatic, if questioned, would insist that he was vouchsafed a clearness of vision and an insight into truth denied his critics. It is only a bit of mental hygiene for one to confess himself to be in such a state, but in this particular case the victim seems to find himself among a group of glorious companions.

When I read Washburn's emphatic assertion that she is "prepared to defend the unity of the physical world," I am overcome both with admiration and with amazement. When Weiss declares that "Everything is a movement," I wonder what is the matter with him. When the motor and glandular behaviorists deny the existence and importance of aches and pains in nature, words cannot do justice to my astonishment. When the physiologist intimates that consciousness is the

[1] Presidential address delivered before the American Psychological Association at Columbus, December 29, 1927.

caper of a cortical neurone, I am stirred to argument. When Titchener insisted that "Meaning is not a constituent feature of mental processes," I was sorely distressed. And when Koffka asserts that "Only events accessible to the many are to be called *real* things," I am driven to expostulation.

These reactions seem especially justified since, in all these cases, and in many others, the truth seems to me to be so obvious. And herein lies the delusion. The topic chosen, as it happens, is the one announced on the program, and you have already wondered how any one can talk for an hour on such a theme.

Higher and Lower Senses in the Fine Arts

Are there sensuous determinants of psychological attitude? Certainly there are such restrictions in other fields. On the development of the fine arts, for example, the limitations of the senses have exercised a remarkable influence. The rough and ancient classification of the 'higher' and 'lower' senses reflects genuine differences in the esthetic possibilities of sensory materials. It suggests also an ethical and social evaluation. It is primarily an indication of the fact that the limitations of the modes of sensation set definite bounds upon the elaborative activities of the artist.

But there is some special reason why the sense impressions with high esthetic possibilities are those which are genetically the most recent, in imagination the most capable of clear and persistent revival, pertaining mainly to the distance receptors, informing us of objects which may be socially shared, and capable of systematized and organized description. This further reason is the fact that the task of the artist is first of all the communication of a *meaning*. It is the capacity of the various sensory modes to act as vehicles of meaning that sets limits upon the materials of esthetic manipulation. Now there are sensuous determinants of scientific systems as well as of esthetic activities, and the problem of *meaning* is as crucial in psychology as it is in the theory of art.

Interoceptists in Psychology

In the development of psychological systems also the senses and their limitations have played a determinative rôle, and it is the significance of this type of determination which I am here interested in considering. The warring schools of psychology can, without undue distortion, be grouped in two great classes, which may be designated by the rather awkward though instructive terms, *interoceptists* and *exteroceptists*. The distinction is not an unfamiliar one. It closely resembles that between 'internal and external behavior,' which embodies a sound idea in unfortunate terms. On the one hand they too closely resemble 'implicit and explicit movements.' On the other hand they too readily suggest the mediæval distinction between 'inner perception of mind' and 'external perception of nature.' It seems best then to employ the long and awkward terms I have chosen.

On the one hand is the fair-minded interoceptist, with his bias for qualities. The first fact that strikes him is the obviousness of the classification of sense qualities into modes. Indeed, beyond this classification and its details he gets only with difficulty. Moreover, being fair-minded, he seeks diligently to assign equal status to kinesthetic, olfactory, visual, and all such other types of objects as he encounters.

Some of these groups are so meager in their aspects of relation, structure, organization and associative efficacy that he charitably takes them as his pattern. He would exclude from vision, for example, those complex aspects, the relational and structural features, which distinguish it, or which it acquires in coöperation with kinesthesis in what we come to know as the spatial world. Wherever possible he shows that visual structure is reducible to visceral quality. This habit becomes inveterate, and relations are everywhere tabooed and eluded.

It is difficult to see why this is done, except through a motive of poetic justice. Surely even the simplest describable sensuous components, say the film colors or the unlocalized bright pressures, display relations, as well as quality. If

these qualities be mental components, relations are found among them—relations at least of succession, of difference, of degree in all the attributes. It is indeed striking to see the diligence with which relations and meanings are reduced to quivers, attitudinal feels, flashes of cold, and the like by the interoceptist. I can account for this only by ascribing to him a bias away from the higher senses and a firm determination that the lower qualities shall have a prestige which nature has denied them.

Psychology of the Exteroceptist

Contrasted with this particular bias of sensuous determination is that of the exteroceptist. He is more commonly called a behaviorist, and his passion is all for vision. According to this school, as I understand it, the only objects comprising the world are visual in nature. Hence visual observation, direct or indirect, is the only method to be utilized in science. If other than visual objects do perhaps exist, they are at least to be studied only through their visual manifestations or through correlated visual phenomena. Only with reluctance is occasional permission given to take advantage of auditory observation, as in the noting of cries on the part of lower animals, or the speech reports of man. But the account of all objects in the lower sensory modes is rigorously excluded from psychology. This is often called the point of view of 'natural science'!

Thus if with my arm I execute a gesture, the exteroceptist may study it as a movement, visually apprehended by him. The fact that I also apprehend that gesture, not through vision alone, but also through the avenue of kinesthesis, the behaviorist ignores. The movements which are correlated with a toothache may be studied, but the ache itself, as a non-visual event, must not even be mentioned. For this would be introspection! This would be to admit a world of objects not directly accessible to the visual investigator. An upright exteroceptist denies psychologists the right to observe smells, tastes, pains, and the great array of thermal, tactile, kinesthetic and affective objects. He does this simply

because such objects cannot be seen, and will not inscribe themselves on smoked drums. Since only his own hurts come home to him, the exteroceptist is ready to deny the existence of aches, pains, migraine figures and after-images. When the behaviorist says 'objective' he means 'visual.' Of course the actual founder of this school was Mrs. Eddy.

This restriction of the world of legitimate objects to those of a visual character (in the main) seems to be the one positive principle of the behaviorists. Observation of all other kinds of objects they deplore, as the mere 'exploration of consciousness.' They dismiss such objects with a wave of the hand, remarking that they are sceptical even of their existence, and thoroughly convinced of their unimportance. Or, if we try to be as lenient as possible with the exteroceptist, the very least we can accuse him of is that he supposes that in some way visible objects are more 'real' than events of other kinds, and that for this reason they are more worthy of investigation. Such a doctrine has a strong appeal to large numbers of people who can pronounce the word 'psychology' but are unable to spell it.

There might of course be merely an exteroceptive personal preference for visual activities. Since these are relatively easy to observe, tend toward uniformity and consistent report, data in this field accumulate rapidly and readily make an impressive showing. But such a point of view would stand in the history of psychology merely as an unimportant individual taste. The future historian might then surmise that whereas Albert, let us say, was content with easy problems, Raymond, for example, preferred to tackle more difficult jobs. But the unfortunate thing is for such personal preferences to obstruct science, to side-track progress, and to discourage the productiveness of young converts. All of these the behaviorist bids fair to accomplish if he is allowed to have his way.

Historically of course this attitude was a vague reaction against the interoceptists, who adopted a frank trinitistic stand, and distinguished carefully between objects of consciousness, their stimuli, and the body. It was the current

preoccupation with 'purely psychic' objects which provoked the exteroceptist revolt. The contrast is illustrated by the fact that there could scarcely be a blind behaviorist, whereas blindness in later life should make the structuralist a paragon of inspective excellence.

This attribution of sensuous bias is, however, not suggested with slanderous intent. The bias of vision has ecclesiastic approval and the sanction of the fine arts; the bias against vision we have attributed to the noble impulses of impartiality and poetic justice.

Data and Problems of Science

But what type of psychology is possible if we seek to avoid the sensuous bias? Such an attempt leads not only to a redistribution of emphasis, but to a far-reaching systematic adjustment, to greater preoccupation with relations and structures. It leads perhaps to metaphysical and epistemological entanglements almost as severe as those which the biased schools so gleefully ignore. I venture briefly to sketch the outlines of such an account.

The modest task of the scientist is that of systematically describing a portion of the world, a world in which are encountered such items as attributes and qualities, relations and structures, objects and events. Some of these items may be unique and uncorrelated with others. Those which will occupy the scientist, however, are intercorrelated in various ways. Moreover, some of them are the reports or symbols of other events—they are signs or fragments of previous larger wholes.

The rainbow and the star are such primary objects—visual, kinesthetic, relational and affective structures, with no olfactory or gustatory correlates. The migraine figure is another—a visual structure with correlates that are chiefly visual and affective or algesic. Sticks and stones, pains and odors, emotions and strains, sense images and memories, are also encountered in the same world. The various sciences enumerate, describe, classify, analyse and correlate these diverse events.

When the correlations break down, hypothetical events are introduced, convenient fictions, such as demons, vapors, forces, vortices, protons, atoms; or synapses, ideas, instincts, intelligence, purposes and libidos. Or numerous particular observations are grouped together, on the basis of some resemblance, giving rise to a general name, which is readily construed into a determining agent.

Thus numerous gravitations generate 'gravity,' and numerous straightforward acts generate 'mental set,' 'will,' and 'entelechy.' These so-called super-phenomenal entities are of course only the names of such general groups of similar events. Still oftener, reports of events are accepted in the place of events themselves, and function for them until their testimony is invalidated by the march of other events. Where does a psychology without sensuous bias take a hand in the account of such a world?

Privacy and Coöperation

First we must handle the problem of coöperation. The coöperative aspect of knowledge is often held to complicate epistemology. But this social feature need offer no difficulty to science. As a child I hear the words 'There comes father,' whereupon occurs that more elaborate visual-auditory-kinesthetic-affective event which the words denote, and in terms of which subsequent events are conditioned. Thereafter the words 'There comes father' lead by themselves to just such consequents. One object, as Edmund Burke long ago emphasized, is thus the surrogate for another, and functions for it even in its absence. My thinking and acting are determined by the past contexts in which father did approach.

Thus science becomes a joint enterprise, because consequents are determined not only by original events but also by others which are their reports. In time reported events are accepted which are never otherwise known to the scientist. A neighbor reports the advent of a pain, a shame, a non-localized bright pressure, just as he reports the approach of father. That we should suppose the one to be an objective occurrence and the other a bit of his private consciousness,

leads to interesting reflection on the natural history of man and his language.

The privacy of the neighbor's pain and shame (they are known to others only through their surrogates) gives them no peculiar ontological status. Nor does their brevity, their inconsistency, nor their qualitative simplicity. The world of consciousness is the world of past events, now symbolically reported. The consciousness which I attribute to my neighbor is either his capacity for such report or else the inferred series of objects reported. Description of consciousness is only the symbolic indication of this field of unverifiable objects. Lucid formulations recently given by Hunter, Lashley, and Wheeler are in good accord with this account.

These objects reported by my neighbor are like the absent objects of the physicist. Except for the neighbor, they are assumed or reported objects, convenient fictions, indicated by signs. That the sign is in the one case a word or gesture, in the other a change in volume or temperature, is an interesting fact, of no systematic importance for psychology.

The Psychophysical Continuum

The world thus offers a continuum of items, ranging from such variable and inconsistently reported items as pains, feelings, and after-images, at one extreme, to the stable and consistently reported sticks and stones of commerce at the other. It is the consistency of report that first enables us to trade and barter in the latter, whereas our traffic in the former is limited to contemplation and description. We can sell a wheelbarrow, but a toothache we can only suffer and describe. But both are objects, encountered in the world, and differing also in complexity, persistence, in their various correlations, and in the type of sequence they exhibit.

Between these extremes lie long stretches of intermediate items—the beauty of things, their temperature, distance, their harmony and discord, their value, and various relations —all these having a psychophysical status which is equivocal. They are more stable and consistently reported than aches and pains, less so than sticks and stones. Our bilateral

symmetry has imposed upon the morphology of language such constraints that we usually ignore this great intermediate realm which is not unambiguously subjective nor objective, mental nor physical, quality nor stimulus, function nor structure.

The mental sciences have dealt with the most variable items, the physical sciences with the least variable. The indeterminate intermediaries have either been left to logic, mathematics, medicine, grammar, esthetics and jurisprudence, or incidentally and apologetically referred to by the sciences of the right and left wings. Thus arise mind and matter, soul and body, appearance and reality, experience and stimulus, all artificial cleavages, suggesting yawning gulfs which thereupon constitute insoluble problems unless one take the genetic approach to them.

The Problem of Meaning

Naturally enough, testimony agrees better on total trends than it does on minute details. Witnesses agree that two machines collided. But whether A bumped B, or B bumped A, or whether fender, bumper, hub or radiator was involved will be a matter of dispute. So in all testimony, total events bring concordant report on the larger issues. Hence these total events are called stimuli, meanings, or real objects. The more minute, partial, sundered and abstracted the item reported, the greater the disagreement. Hence fragmentary abstractions, such as particular qualities, attributes, and the like, being discrepantly reported (either to one's self or to others or by others) are called experiences, mental items, which only *point to* or *mean* their original totals. *Meaning* thus becomes the first as well as the final problem of psychology, as we found to be the case also with the fine arts.

Thus a recent authority for the interoceptists writes:

> To know how mind is composed is to know . . . the processes which taken together make up the flow of experience.
>
> Outside objects are what the experiences mean.
>
> The visual qualities which arise as I look from my window mean 'eucalyptus tree.'

> Only mental existences . . . have the property of referring beyond themselves.
>
> The 'form of the tree' is said to be a fact independent of experience, while 'my hearing of the wind' is a matter of experience.

Mental items, we are thus given to understand, point to items outside of experience. But if the form of the tree lies outside of experience, is it not strange that we know so much about it? Just what then does the interoceptist mean by 'outside objects'? Outside the body, outside experience, outside the present moment, or outside the mental item itself?

If meanings are stimuli and these lie outside experience, is it not strange that the experimenter has such command of them, can apply them or remove them, describe, classify and measure them—these non-experiential stimuli? What the structuralist means by meaning I fear we shall never know, except that it is for him a holy mystery. For when he essays an account of it he invokes a holy trinity, at least two members of which are illegitimate. Experience, the body, and the stimulus—of these three, experience has an honorable status, but the body and the stimulus have a shady origin. They speak strongly of a dissolute philosophic past, which perhaps justifies their exclusion from experience.

Occasionally the interoceptist gives way to a suggestion that meaning does as a matter of fact lie entirely within experience. Thus Bentley writes:

> The visual complex may itself mean softness or warmth or weight or yieldingness. These qualities . . . have previously been acquired by contact; but, later, vision stands as a real surrogate for touch and takes over the offices of the original experience. ('The Field of Psychology,' p. 147.)

It is this admission that is the salvation of psychology. Here meaning is not occult reference beyond experience, indwelling universal, mere logical implication, momentary context, nor mystic component of the soul's structure. Meaning is surrogate function. Surrogate function is indeed what constitutes the mental, and is in large measure responsible for the variability and inconsistent report of what tradition calls psychic events.

I have tried in recent years, in a scattered series of papers, to express this point of view and its bearing on systematic psychology. With your indulgence I now try to state in brief the way in which this account runs, as an attempt to give a psychological picture unhampered by a sensuous bias.

Experience, the Body, and the Stimulus

First of all we must rid ourselves of that trinity—experience, body and stimulus. Unless we start with a sensuous bias, these are not three but one. And they are moreover, neither one nor other of these three—neither body, mental component, nor physical agent. All these are but classifications of the 'neutral stuff,' the psychophysical continuum of events which comprise the world. Their supposed puzzling interrelations are only correlations of natural events.

Thus the 'mental items' are natural events that are variable, uncertain, reported with contradiction, and which instigate that type of sequence which we call redintegrative. The partial detail has the instigative efficacy of a previous total context. Consequents do not rigidly follow fixed antecedents, but are touched off now by this or now by that fragment of an earlier antecedent. Such redintegrative and hence descriptively elusive sequences are what we call mental events. Other and more rigidly determined sequences require the total antecedent for the instigation of the consequent. These sequences we call physical, and they are not only regular but admit of consistent report.

Sticks and stones, the body and brain, are such 'physical' events. Aches and pains, sense images, kinesthetic patterns, emotions and the like, fall with differing degrees of completeness into the 'mental' category. Numerous other items, as we have indicated, have an ambiguous status, even more ambiguous than that of the emotion and the odor. What we call the body is obviously an incorporation of certain of these natural events. It may be correlated with others like it, as in biology and physics. It may be correlated with the more variable items also—with pains, moods and after-images—just as these may be correlated with one another.

But the correlation implied in the mind-body relation is no different from the correlation of two 'physical' events, as volume and pressure of a gas, or two 'mental' events, as the hue and brightness of film colors. All events take their place in that continuum which we call the world. It is quite unnecessary to insist on a gulf between them, just because our bilateral symmetry has imposed dichotomy upon our vocabularies. It is equally unnecessary to talk about the two extremes as if they were fundamentally two different sorts of being, or different realms, with strange relations of dependency, parallelism, identity, double aspect, or what not.

So much for two members of the trinity—experience and the body. What now of the stimulus? And what of the stimulus error? "The stimulus," writes a recent authority for the structuralists, "is to be described in the standard terms of physics or chemistry; never in terms of the mental process and never in terms of the object which the observer perceives."

Are we not here again confronted with a sensuous bias? We may assume that this account is not a mere piece of casuistry, implying that *however* the stimulus may be *identified* it is safer to *describe* it in terms of the prevailing physical fictions. Such casuistry would mean that in one century the stimulus was a collection of effluvia, then the pellucid, then the caloric, then phlogiston, then corpuscular movement, then ether vibrations, and yesterday some form of electromagnetic radiation.

Psychology does not really go to physics to learn about the stimulus. Physics begins with a visual event, and terminates with a visible indication. Between the two, to be sure, it takes various liberties. This is at least one of the reasons why modern physics is so obsessed by the velocity of light.

No, the secret of the stimulus is not to be found in the world of physical constructs. Nor, as the quotation insists, is the stimulus 'the object which the observer perceives.' Of course the stimulus is really the object or situation which the *experimenter* perceives, or supposes that he does. We

have called it the *antecedent.* The *consequent* is either another event similarly perceived (what the reaction psychology calls a 'response'), or else it is a reported event, described by the subject. Or if he be experimenting on himself, the *stimulus* is *one aspect* of a total event, the other or later aspects of which will constitute the consequent. Meanwhile the *body* to which the stimulus is applied, and the *brain,* are similar and correlated events. The correlation of all these events is what constitutes the observation.

The structuralist's distinctions between the world of stimuli and the world of conscious processes thus fades away. Warnings concerning the 'stimulus error,' distinctions between report of process and report of meaning, are seen to rest on epistemological prejudices or on inadequate vocabulary, rather than on phenomenological fact.

The stimulus, for example, is not a non-psychological object which the experimenter can hold in his hand and which the subject may know by intuition or by intentional reference or through immanent meaning. Nor is it a physical object to be sharply distinguished from a mental content which refers to or means it. The stimulus is only an event complex partially described, or considered in but one of its aspects. As Kant intimated, the thing-in-itself is only "the same thing regarded from another viewpoint."

Gestalt Psychology and New Realism

There have been in recent years signs of a structuralist retreat from the original and naïve trinitarianism. The rise of 'gestalt-theorie' is a natural extension of the earlier contributions of a long line of protestants. It may perhaps indicate an abandonment of the old stimulus-process distinction, and a recognition even in psychology of that fundamental fact which we have tried to suggest by the awkward term—the psychophysical continuum.

A similar movement on the part of philosophers is found in that enterprise which in America first became conspicuous in 'the world of pure experience' of William James. More recently the neo-realists and the critical realists have compli-

cated the terminology and thus valiantly perpetuated the study of philosophy. In the pure experience of James, in the neutral stuff of the neo-realists, and in the essences and logical entities of the critical realists, we find only a technical rendering of the psychophysical continuum—that background of events, *within which* we draw the popular distinctions of mental and physical, sensation and stimulus, process and meaning.

It is questionable, however, whether either of these movements offers much positive contribution to psychology. The 'gestalt' psychologists, in the main, are 'structuralists' in the old as well as in the newer sense. They tend to abide by a special and isolated world of psychic data, with the description of which they are occupied. The preoccupation of the older structuralists with abstracted qualities and attributes and with the phenomena of attention, they seek to compensate by the intrusion of form and organization, structure and background. This however is only a clandestine way of smuggling into the psychic field the relations which the sensationalists persistently evaded. The traditions of body, stimulus and experience still linger with this new structuralism. It is far from clear that structuralists will ever realize that once the facts of pattern and organization are really admitted, we move no longer in a world of psychic and physical abstractions, but in the actual continuum of natural events—in the geography of life rather than in the limbo of fragments.

And from the philosophic movement little positive contribution is to be expected. Realism rests with a negative warning, with the resolution of conventional distinctions into the neutral background. And 'pure experience' no sooner begins to breathe than it is contaminated with distinctions. The positive solution of the psychological dilemma must come from an active psychology which succeeds in maintaining the integrity of experience while yet permitting it to propagate and to prosper.

Functional and Descriptive Concepts

The point at issue is closely involved in a distinction often made between functional and descriptive concepts. As a concrete illustration we may use the account given by Koffka who says:

> Facts which *anyone* can determine are called *actual* or *real* things or processes. But we must also introduce a term for facts which can be established only by *a single person;* these we shall call *experiences* or *phenomena.* In order to define real processes we shall use *functional* concepts, whereas the concepts we apply to experiences we shall call *descriptive* concepts.

The example is that of a person with whom I had dealings yesterday and who greets me today when he meets me on the street. "I therefore say that he has *recognized* me, and I refer this fact to his *memory.* Any one to whom the factual material is available" can attain this concept of memory, which is therefore a *functional* concept and indicates a *real* fact.

However, the man who greets me, thus leading me or others to infer an operation of his memory, may express himself by saying, "Your face, which yesterday seemed strange, now seems familiar." No one but the man can report this 'familiarity.' Familiarity is *therefore* an *experience*, not a *real* fact; it is a descriptive concept, not a functional one.

What a strange notion is this, which denies reality to the actually observed, and attributes it freely to the postulated? What now are the actual facts of such a case? The 'greeting' is an event describable in visual terms (account of nod and smile). The 'familiarity' however is not a visual event, but one of another mode—perhaps organic, kinesthetic, affective. Both, as a matter of fact, can be established, to use the words of the author, "by all to whom the factual material is available."

The 'greeting' may, if you like, be referred to some such category or descriptive abstraction or class of events as 'memory.' But so also may the 'familiarity' be referred to a more inclusive category, such as recognition, or feeling, or attitude. Descriptive and functional concepts, that is, are

as applicable to one set of factual material as to the other. The fact that many people may consistently report the 'greeting' while only one encounters the 'familiarity' is an interesting statistical fact, but nothing more.

Nor is the *descriptive* concept peculiar to psychology. Physiology and physics also require 'factual material' (usually visual events) before they can step over them to their *functional* concepts. Koffka simply forgets that the greeting has to be *seen*, as the familiarity has to be *felt;* in other words, that both of them have to *occur*. The *visual greeting* must then be included along with the *felt familiarity*, in the descriptive material or factual data, no matter how many reporters have 'access to the material.'

Psychology thus does not differ from the other natural sciences in the character of its concepts. There is merely a difference of emphasis. Physics steps over the visual material, the descriptive events, to preoccupy itself chiefly, though not entirely, with its functional abstractions and generalizations. Psychology, on the other hand, often gets tangled in the factual materials. Thus, in the case of the 'visual greeting,' psychology also soon steps over the primary events to the generalized abstraction of 'memory.' But in the case of 'familiarity' it is still chiefly occupied with the description of the primary observations. It has not yet undertaken an adequate account and explanation of the *behavior* of 'familiarities.'

The only genuine distinctions involved here are (*a*) the modality of the primary data, and (*b*) the statistics of report. Both of these the gestalt psychologist fails to see in their full implication. In the first place he unjustly ignores the descriptive material involved in the occurrence of the 'greeting' as a visual event. In the second place he mistakenly supposes a great gulf to exist between *data accessible to the one* and *data accessible to the many*. For there are various degrees of availability and of unanimity of report, both of which expressions mean the same thing. One has only to remember the blind, the deaf, the demented and the imbecile, to realize the error of supposing a sharp distinction to exist between

the real and *the phenomenal.* The number series is a continuum, and, as I have already frequently insisted, so also is the world of natural events.

Scholasticism and the Non-sensuous Bias

Before proceeding with a suggested positive contribution, it is only fair to remark that in addition to the types of bias within the sense modalities, there is another prejudice which has also left its mark on psychology and still has an active following. This is the bias away from the whole array of palpable items, in favor of a special field of non-sensuous objects—the relations. The names of Brunswig, Moore, and Spearman will serve to indicate the general content of this neo-scholasticism.

It is unnecessary to amplify the fact that a non-sensuous prejudice is as strong a determinative as is an interoceptive or an exteroceptive bias. Perhaps the greatest systematic virtue of the 'gestalt' movement consists in its refusal to abstract either the fundaments or the relations from the total configuration; its insistence that the unit of occurrence is the organized structure. From this point of view the doctrine represents a systematic compromise between the sensationalists and the scholastics—a commendable compromise between a pro-sensuous and a non-sensuous bias. If this doctrine some time achieves an adequate account of its 'stimuli,' it may be found to have made an abiding contribution to systematic psychology.

A Psychology without Sensuous Bias

Without sensuous bias, then, and confronting the continuum of events, with the two types of correlation—the mechanical and the redintegrative sequences, what might we expect the psychologist to do? First of all we might expect the delimitation and description of those items sufficiently variable, and those events sufficiently redintegrative, to afford him occupation, and to suit the contemporary division of scientific labor. Such an enterprise might well occupy half of the textbook which such a psychologist would prepare.

If he did not exercise great caution, he might begin with the larger complexes, chief among which would be those elaborate events which we call organisms. Some of their phenomena are extremely incalculable, and many of their changes follow the redintegrative pattern. Preoccupation with these objects (either people or lower animals), which are known almost exclusively in their visual aspects, would make of him a kind of naturalist, occupied with the behavior of these chiefly visual complexes, their spatial adjustments in the main. Storms, earthquakes, and forest fires he would ignore, because, however incalculable they may be, they are in the first place consistently reported, and in the second place, they are lacking in redintegrative sequences. Even such organic changes as growth, reflex action, metabolism, and the like, he would ignore except in so far as redintegrative phenomena were discovered in them.

So preoccupied would such a naturalist become with the enormous array of tasks calling for visual exploration that he might in a moment of vexation or trial malign all psychologists who did not come to his rescue. He would thus be yielding to a sensuous bias. He might even become so visually obsessed as to deny the existence of the non-visual objects engaging the attention of others.

These others! What of them? Let us suppose instead of our visually obsessed naturalist, a psychologist with a non-visual bias. Perhaps he suffers from inferior visual acuity, poor color sense, eye-strain, astigmatism, faulty optical coördination, or inadequate orientation in visual space and in the visible geography. But his other sense fields are rich and lively, and these preoccupy him. His favorite objects of scrutiny and description are not the visual complexes of the behaviorist, but the patterns of kinesthesis, the panorama of tastes and smells, the structures of pain, strain, and pressure, and the fusions of sound, sense image, and simple or complex feelings.

These objects also have their organization and behavior, as do the visual patterns of the exteroceptist. Felt emotions are no less active than are visible ones. But their relational

and structural aspects are meager, their qualitative range limited, and their behavior and correlations correspondingly simple and restrained. Taking them as his schema, he minimizes the elaborate, relational manifold of vision and touch, reduces it where possible to surrogates from the lower qualities, and seeks to swell his chapters on kinesthesis, strain, sense images, and the tactual and thermal objects located in the esophagus.

Most of these objects he finds so correlated with others, including oral reports, which are also objects, that he comes to assume that he alone confronts them. They are private objects, subjective phenomena, items of experience, conscious processes, to be sharply distinguished from the world of visual events (his stimuli) on which different reports agree so unanimously. And he would hasten to include in his account of the psychic world such visual objects as do manifest obvious discrepancy of report or variable correlation, such as entopic phenomena and illusions of reversible perspective.

But he would in all this have slipped again into a sensuous bias, as did the one before him. Both individuals would, moreover, train up a group of students who failed to comprehend the genetic history of the prejudices presented to them. They might either adopt these, parrot-like, or move to another master whose sensuous bias was more in keeping with their own, or perhaps become only a medley of different biases through their miscellaneous reading. Of course I have much over-simplified this account, and if it interests you at all, you have many objections and conundrums. Do not fancy that the simplification is because there is nothing more to be said. It is only because we must hasten to the consideration of our final topic. This concerns not the differentiation of the interoceptists from the exteroceptists, but, instead, the significant fact that aside from the biased tendencies here indicated, they treat of much the same array of topics, only in somewhat different terms.

The interoceptive events, such as pains, sense images, feelings, kinesthetic patterns, manifest the same redinte-

grative sequences as do those exteroceptive events which we call visible organisms. It is unnecessary to choose between anthroponomy and subjectivism, for visible animals, in their psychological aspects, follow the same laws as do emotions, sense images, aches, and kinesthetic objects. The laws are those applicable to redintegrative sequences, chief of which is that a partial detail of an antecedent may thereafter assume a substitutive rôle in the instigation of a consequent. I may be pardoned for re-stating this principle in detail at this point, since it is so constantly and erroneously confused with another conception for which the same name was used by Hamilton, Bradley and James.

The Principle of Redintegration and Its Applications

Given *ABCD*, a complex antecedent, followed by *XYZ*, its consequent. Thereafter the fragment (*a*) alpha, a detail in the same class with the original *A*, is effective in instigating *X'Y'Z'*, a consequent in the same class with *XYZ*. This gives the meaningful situation, confessedly the crux of all psychological problems, beyond the mere description of components. In this situation alpha, the instigating detail, is the *Sign; ABC*, the original complex antecedent, is the *Signified; XYZ*, the consequent, is the *Significance;* and the fact of sequence itself is the *Signifying*. It is well to use these terms instead of the loose word 'meaning,' which is applied now to one, now to another, and sometimes to all these features. This schema, with the various detailed laws that qualify its occurrence, is the fundamental psychological pattern. Proceeding without sensuous bias, we can fit into it the life of animals, the conduct of sense images, the behavior of pains, the activities of speech, the phenomena of emotion, the processes of reasoning.

For the instigating detail, *a*, may be an item or event from any region of the psychophysical continuum, and the same may be said of the consequent. There is some practical convenience in classifying the consequents, according to their character. They are postural, autonomic, or symbolic,

corresponding to the ancient distinctions between doing, feeling, and thinking. This is convenient both in dealing with those exteroceptive objects which we call 'other organisms,' and also with the course of those interoceptive events which we call mental processes.

Thus in any meaningful situation, in what we commonly call 'understanding,' the instigated consequent may be a useful motor adjustment, an adequate emotional appreciation, or an appropriate symbolic indication or synonym. Unsagaciously redintegrated consequents on these three levels give us also the three characteristic clinical pictures in the psychoneuroses.

I cannot here take the time to show the very significant differences between this process and the current 'conditioned reflex' theories. I can only intimate that the conditioned reflex is but half a description of the simplest possible mental or redintegrative situation, and even then represents but one of three forms of redintegrative pattern. There are various other differences also.

The pattern includes at least three forms or modes of part-whole efficacy. In the first, an *essential component* of the original total antecedent becomes effective. In the second, some *incidentally concurrent detail* is rendered effective —this being the ordinarily described 'conditioned reaction.' In the third form, there is instead merely a *reduction of the required stimulus intensity*, as seen in the lowering of effective thresholds in many conditions of ordinary practice. *Partiality*, *concurrence*, and *reduction*, these represent the three principal modes of redintegrative sequence. In all three cases a partial feature is seen to function as the surrogate for a more elaborate antecedent context, in the instigation of a consequent.

A Few Concrete Instances

Bear in mind that both the interoceptist and the exteroceptist have already enumerated, described and classified such items as they wish to handle. Within the chosen fields each works with very much this same pattern when dealing

with processes, functions, acts, as distinguished from the mere account of components. Perception, habit, memory, association, imagination, reasoning, voluntary action, all follow the paradigm.

In each case, after the recognition and application of the paradigm, fundamental problems arise concerning the nature, number and locus of the instigating antecedents, the character and circumstances of the past context, and the particular and generic features of the consequent. Certain collateral problems also arise concerning the various aspects of the part-whole substitution and the process of instigation—such as time relations, conditions of variation and permanence, and correlations with other phenomena.

Time does not now permit the elaboration of all these illustrations, many of which I have developed in other connections. But a few brief indications may be useful in illustrating the application of this paradigm to what we may suppose might well be the second half of the textbook written without sensuous bias, by the psychologist who moves freely through the psychophysical continuum.

It is this redintegrative process which underlies the classical act of 'supplementation' and the more modern act of 'closure' in the typical cases of *perception.* The supplementation was a fiction and the closure is a fantasy. What actually occurs is that an incomplete presentation touches off the consequent which would be appropriate to the presence of the total. This also is *insight.* Nothing is 'supplied by imagination,' and there is nothing that 'closes' or 'completes itself,' whether 'in the mind' or 'in the physical situation.' The present detail functions in the place of an historic context. The consequent may be overt reaction, attitude or emotion, verbal report or other symbolic event; in any case it is instigated by a fragment of its original stimulus. Supplementation, closure, and complex completion are but mystical names given to the simple fact of redintegrative sequence.

The redintegrative paradigm describes not only the course of *emotional transfer* and organization, but through it also

graduation is imposed upon the original 'whole-heartedness,' the 'all-or-none' tendency of such activity. For the response to a fragment or an associated detail is often less intense, less extensive, less prolonged and vigorous than is that to the original total situation. Through this fact, and through the *constellation* of details, the various gradations of emotional response are accomplished.

Perception, to continue, is the simple redintegrative operation of a detail. *Motivation* is the specifying operation of an enduring detail in bringing to readiness a field of consequents, one of which will be touched off by the instigating detail when it occurs. *Reasoning* is the joint operation of these two details, the specifying and the instigating, when the consequent is itself a symbol or plan. *Voluntary action* is a similar joint operation, when the consequent is some completed overt act. The details themselves, fragments of previous contexts, are what we call *thoughts* or *ideas*. The fact that they function vicariously is all that is involved in the profound mystery of *transcendent reference* or *implication*.

In *memory* the past context is not only vicariously represented, but the consequent is another symbol of the same past context, as for example, a verbal designation. *Learning* is merely the reduction of the required antecedent, as slighter and slighter cues become effective; learning is the process of cue reduction, and this is what makes of it a mental process. Learning is not the lopping off of useless responses; there are no 'random movements,' and no experimental animal ever acted at random; instead it was the experimenter who built his cage or maze at random. Learning is a change in the required stimulus, not a change in the response; and the law of effect operates by modifying the stimulus, not by mystical changes in the movements.

Intelligence is precisely this capacity for symbolism, and it varies with the degree of possible reduction of the required cues to action. *Sagacity* is discrimination between relevant and irrelevant details in the redintegrative process, and depends upon adequacy of scope for all the details available in a given situation.

The more formal processes also lend themselves to the paradigm. *Observation* is the immediate encountering of an item which instigates, as a consequent, its report or name. In *judgment* the report of a situation is instigated by a surrogate item or situation, belonging in the same class. In *inference* report of a situation is also instigated by a surrogate, but by one in a different class from that reported. In the case of *belief* the instigating surrogate is itself the testimony of another reporter. In the *syllogism*, the subject is the present detail; the middle term is the past context; the predicate is the instigated consequent.

The same principle of description and explanation applies in an instructive way to such apparently remote phenomena as reading and hysteria; thinking and optical illusions; syllogisms and space perception; animal training and esthetics; sleep and salivary secretion; dreams and typewriting; language and the telescoped reactions of Stentor; recognition and totemism; patriotism and the scarecrow; primitive magic and the conditioned reflex. Woodworth has appropriately illustrated this principle in various applications of what he calls 'the law of combination.'

Conclusion

We may seem now to be far from the title of my paper, both logically and chronologically. But psychologically we are still in close touch with it, since we have sought to avoid that predicament which the title denotes. The essential things I have tried to say may, in conclusion, be summarized in three brief propositions:

The present turmoil in systematic psychology is, in part at least, the consequence of sensuous determination.

The future concord of our science may be achieved only by transcending this bias.

I propose the psychophysical continuum and the principle of redintegrative sequence as useful aids in effecting this transcendence.

You have now been intimately admitted to the obsession. No doubt the diagnosis is 'Constitutional Psychopathic

State' and the prognosis 'gradual deterioration and decline.' But I hasten to assure you that the patient already feels a great relief. The latent content has now become manifest, and this catharsis, along with the sense of an accomplished duty that will never recur, bring peace to the 'unconscious.' Conflicting libidos are amicably reconciled, and all the free-floating affects have found adequate posts of anchorage. The transference is complete, and my indebtedness to you, my physicians, is beyond the bounds of payment.

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THE PSYCHOLOGICAL THEORY OF FORM[1]

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I. 'Configuration' as Order of Sensory Elements

The starting point of the 'Gestalt-theorie,' the new psychological theory so prominent today in Germany, may be stated as follows: If we observe three differently colored points, one yellow, one red, and one green, we receive from them three elementary sensations, namely sensations of yellow, of red, and of green. But it is evident that these three elementary sensations are not sufficient to give us the arrangement or order of the three points under consideration. These points may be arranged along a straight line, or they may form the vertices of a triangle which may have the greatest variety of shapes. What, ask the configurationists, is added to the three elementary sensations to give us the perception of the arrangement or order of these three points? Or, more exactly, what is the physiological correlate or basis which corresponds to this arrangement or that particular order of the three points?

It must be admitted that the English association school did not go deeply enough into this question. A landscape, they said, reflects its own true image upon the retina. To various retinal images there must correspond different systems of excitation in the nerve centers and it is these systems of central excitations that constitute the physiological correlate or basis for the perception of the landscape itself. And they went no further than this; they did not attempt to carry out completely the investigation of the process.

Now it is an undoubted merit of the configurationists that they have tried to go deeper in this investigation. And their explanation, or at least that of some of the group, is the following: Among the nerve currents starting from the

[1] Translated by the Editor.

retinal endings there are formed, once these currents reach the brain, certain derivative nerve currents, certain uniting or connecting currents, which make a sort of short-circuit, whereby there is established a complex system of neural distribution, whose modes depend not only on the quality of the specific elementary excitations, but also on the arrangement and spatial relations existing among these elements. It is this very complex central distributing system that constitutes the physiological basis of the 'form' of the landscape or object under consideration.

Up to this point configurationism does not differ much from English associationism. The configurationists merely try to specify more particularly the manner in which the arrangement or order of the different points in the outer world from whence the elementary sensory excitations start out, are reproduced in the brain. But the point in which the configurationists differ essentially from the associationists is in denying the qualitative independence or qualitative autonomy of the elementary sensations. They assert, in fact, that the derivative nerve currents, the uniting or connecting currents, react in turn on the primary currents which they bind together, to such an extent that the modality of the primary currents depends, not merely on the specific elementary excitations which originate in the outer world, but also on the internal system of nervous distribution which they effect with the help of the connection currents. To illustrate his theory Köhler takes the example of a distributing system of electric power in a network, where the strength of the current in each link of each branch depends on the mode of complication of the entire system.

What facts do the configurationists cite in support of their hypothesis? We can assert that they do not cite *any*. The experimental fact to which Wertheimer and Köhler attach so much importance—that one and the same collection of points or lines can assume different modes of grouping—is a phenomenon which has nothing to do with the question of the qualitative autonomy of elementary sensations, since it is due only to the mnemonic accretions which are added

to the pure and simple visual impression of the elementary sensations according as they awaken the memory of one object or another.

The qualitative autonomy of elementary sensations *is* demonstrated, on the contrary, every moment by our daily experiences, even those of the commonest sort. It is shown, for example, in dreams, which are characterized by a chaotic mnemonic reactivation of sensory elements, each one of which, though accompanied by other sensory elements absolutely different from those that accompanied it when it was first produced, nevertheless reappears in the dream without the slightest qualitative change.

The qualitative autonomy of sensory elements is also demonstrated by the function of imagination, which succeeds in combining the most diversified sensory elements in a manner wholly different from that in which they actually presented themselves in the past, yet without those elements having apparently undergone any change whatever. For example, the Assyrian lion, with its human face and its wings on the back, presenting a combination of sensory elements entirely unlike anything in real life, does not in any wise modify the appearance of these individual elements nor of their partial groupings, but continues to give one the impression of a lion's body, of a human face, of bird's wings, in just the way that each of these groups of elements appears to us in the real organism where it is associated with other elements. And the painter who creates a fantastic landscape makes use of sensory elements which he borrows from the real world, and which, while they now form part of entirely different sensory combinations, remain identically the same as they were in the world of reality.

We have proof again of the qualitative autonomy of sensory elements in even the most common and familiar phenomena of simple mnemonic recollection, where each sensory element called up is similar to what it was when it previously occurred, although in each new mnemonic recall it may be accompanied by a group of new sensory recollections, more or less different according to circumstances.

Why continue with other examples? The autonomy of each sensory element is demonstrated even by the very experiments of Wertheimer and Köhler cited above, concerning the various modes of grouping which one and the same collection of points and lines can take on, because they show that the sensory elements (these points and lines) remain always the same, whatever the 'reorganizations' or modes of grouping in which they participate.

It is precisely this qualitative autonomy, this *specific invariability* of the elementary sensations, that led us, in our hypothesis regarding the energy mechanism which lies at the basis of memory phenomena, to assume that the physiological correlate of each elementary sensation is represented by a specific nerve current, *capable of specific accumulation.* In other words, in passing from the dynamic state of a current to the potential state—a transformation which occurs when the corresponding sensation ceases and remains stored away (to use Semon's terminology) in the condition of an engram capable of recall or reactivation—this specific current deposits, in the nucleus of the corresponding sensory center, a given substance which, when it decomposes later on, can produce again only that specificity of current by which it was deposited.[2]

On the other hand, the dependence of the local processes which make up the sensory elements upon the whole process of nervous distribution in the optic tract, as assumed by the configurationists, would involve such a great range of variation in the sensory elements according to the existential mode of this general process of distribution, that in the end these sensory elements would be unrecognizable from one instance to another. The result would be a complete subjectivity of the perceptual phenomena. And it is precisely this subjectivity of perception that the configurationists maintain in a fashion quite in line with their hypothesis.

Now the fact that complete agreement normally occurs in respect to the reports resulting from our perception of the

[2] See Rignano, E., 'Biological Memory,' English ed., 1925; Chap. 4, The energetic properties of biological memory.

outer world, is sufficient in itself to demonstrate how little this assumption of the configurationists agrees with reality. What is really subjective, what varies from one individual to another, and even from moment to moment in the same individual, is the affective response, which causes Paul to be interested in a certain part or in a certain fact of the outer world, while Peter is interested in some other part or in some other fact of the same external world. From this it follows that Paul pays not the slightest attention to that which interests Peter the most, and vice versa. And we have no difficulty in granting that Paul may quickly fill out certain sensorial elements presented to him by a swift mnemonic contribution altogether different from that by which Peter would complete this same group of sensory data. This is because Paul and Peter are obeying different affective drives, which arouse in them mnemonic contributions, hasty and transitory in character, that are likewise different. Yet if we should ask either one for an exact perceptual report concerning the presence or absence of this or that object or of this or that relation among several objects, we would get, I repeat, complete agreement under normal conditions.

Upon this perceptual agreement, indeed, is based the common agreement which appears not merely among empirical reports of facts observed under rigidly scientific conditions, but also among conclusions reached by any logical reasoning. Reasoning, according to our hypothesis, is only a series of experiments that are merely thought out; but since we attribute to each the result to which a similar experiment, effectively carried out, led in the past, it follows that every instance of reasoning rests definitely on data furnished by perception; and since these data are the subject of universal agreement, this agreement is reflected in the results of reasoning itself. From this arises, for instance, the general agreement which exists regarding geometrical and mathematical demonstrations in general; hence arises also the recognition of scientific laws and 'truths.' From this, in short, springs the *objectivity* of science.[3]

[3] See Rignano, E., 'Psychology of reasoning,' English ed., London, 1923; Chap. 4, What is reasoning?

It is only when we pass from the data furnished by perception, which are objective and identical for everyone, to the *affective appreciation* of this or that fact, that the general agreement disappears; *objective observation*, provided by perception, gives place, *ipso facto*, to affective appreciation, which is in its very nature *subjective*. But this affective appreciation, subjective in character, has nothing to do with the subjectivity which, according to the configurationists, may be observed in the realm of pure perception.

It follows that the reversal of the English association theory attempted by the configurationists has not succeeded, for they attempt to treat the elementary local processes as functions of the whole, instead of considering the whole as a function of the mode of existence of its elements. We may indeed accept, with the configurationists, the view that the primary nervous currents or elementary sensory excitations, aroused directly by the outer world, give rise in turn, in the central optic region, to derivative, connecting nerve currents (Wertheimer's transverse processes), and that these currents or processes constitute the physiological correlate of the 'form' or 'shape,' that is, of the order in which the elementary sensory excitations are arranged. But to follow this line is to recognize that the fundamental or 'primary' datum in complex phenomena, is made up of these sensory elements which are directly aroused by the outer world, and which arouse in turn, according to their specific character and their order, certain derivative connecting nervous currents. On the contrary, we place ourselves squarely in opposition to this way of regarding the matter if we assume that the 'primary' phenomenon is the complex phenomenon in its entirety, and that this latter serves to determine the mode of each particular excitation, of each part of the whole.

But the configurationists have not merely failed in their attempt to reverse the viewpoint of associationism; they have eliminated all traces of clearness, and have made everything obscure by their assertion that the parts—that is, the sensory elements themselves—are determined by the nature or the properties of the whole, this *whole* being con-

sidered as the *primary phenomenon*. What is the meaning of the term 'primary'? What is this 'whole' which, at the outset, they offer to us as the collection of nerve currents coming directly from the retina, together with certain derivative connecting nerve currents, and which little by little becomes transformed, by virtue of a strikingly Kantian reminiscence, into a container adapted to receive the sensory elements and give them the character of perceptions?

We may say, in concluding this first section on 'configuration' or 'shape' *conceived as the arrangement of elementary sensations*, that if the modern German school of configurationists differs substantially from the English association school, it is not in respect to the essential and acceptable part of their theory, namely, in their hypothesis which assumes the existence of a physiological basis for the *arrangement* of sensory elements, but merely in the artificial additions which in the course of their progress the configurationists have piled up around the original nucleus of their doctrine, distorting it completely and making it wholly different from what it was at the outset.

At the same time, if, by their investigations on the physiological correlate of the perception of the *order* or *arrangement* of objects, and by the hypothesis based thereon (of derivative connecting nerve currents or Wertheimer's 'transverse central processes') the configurationists have supplied a gap in the English association school, and made an important contribution to the progress of psychological science, on the other hand, in their attempt to reverse the mutual relations between the parts and the whole, between elementary sensations and complex sensations, they have only succeeded in spreading confusion and obscurity where, thanks to the clear English mentality, preciseness and clarity had hitherto existed.

We shall find that even more serious consequences arise from other conceptions which the configurationists include under the same word 'Gestalt'—an ambiguous term, with its manifold aspects and its ill-defined boundaries—the exact opposite of that clear and precise demarcation of connotation which science demands for the terms it uses.

II. 'Configuration' as Unification of Sensory Elements and as Meaning of Objects

The second among the more important meanings which the configurationists attribute to their term 'form,' is that of 'unit' or 'object,' by which words they designate the process of integrating the sensory elements.

But in what this integrating process consists—to what mental factor this integrative process is due—that is just what the configurationists never explain quite clearly. From certain passages in their writings we might think that the connecting nerve currents themselves, the transverse functions of Dr. Wertheimer, not only constitute the physiological basis of the *order* or *arrangement* of the sensory elements, but have also the function of grouping these elements into *units*—that is, of distributing the chaotic mass of these elements, received from the outer world, in such a way as to form separate groups, or 'objects,' distinct from one another as well as from their surroundings.

Now this is impossible, because the order of sensory elements and their separation into distinct groups constitute two psychological processes which are *fundamentally different in character*. Order of sensory elements is a phenomenon clearly sensory in character—a phenomenon whose physiological basis must be of the same nature as that of each of the specific elementary sensory excitations, and its physiological basis may very well be made up of those derivative or connective nerve currents, which are themselves of the same nature as the original and primary nerve currents constituting the physiological basis of the elementary sensations. On the other hand, the separation of the elementary sensations into several distinct groups, each forming a unit in itself, an 'object' or a 'thing,' *is no longer a sensory phenomenon*, but is something affective in character—a fact completely overlooked by English associationists and German configurationists alike.

What imprints upon this or that group of sensory elements the character of unity and gives it the appearance of an

'object' or 'thing,' is the satisfaction or dissatisfaction, whether direct or indirect, which it imparts to one or another of our affective tendencies. A certain group of sensory elements—a fruit, a slice of bread, a spring, a glass of wine—satisfies hunger or thirst; another group of sensory elements —a tree or the woolly coat of a sheep—protects us from the burning rays of the sun or from the inclemency of the weather; still another group—a bed of straw or a great stone to be borne from one place to another—affords us rest and recuperation or rouses us to new and painful efforts; each one of these sensory groups becomes *ipso facto* a unit, a *unitary complex* distinct from all others, *and this precisely to the extent that it serves as a means of satisfaction or as a cause of dissatisfaction with respect to one or another of our affective tendencies.*

It is in this affective rebound or reaction that every complex sensory situation finds its resolution or conclusion, and it is this affective response which constitutes precisely that process of separation into various distinct units, which the configurationists have sought for and have not succeeded in finding. It is this, in other words, which supplies the mechanism of integration and synthesis, so that we see 'objects' or 'things' emerge distinctly from the chaos of innumerable infinitesimal sensory elements which the outer world communicates to us.

One of the most serious criticisms to be made against the configuration movement is precisely that it does not perceive this fact, despite the tremendous zeal with which the representatives of the movement have attacked the problem of the organization and the systematization of the primitive chaos of sensations.

But the rôle of the affective tendencies is not limited to unifying the given groups of sensory elements, nor to objectifying these groups as things in themselves, distinct from the confused mass of sensory elements that remain; it is these tendencies, and these alone, that *give a meaning* to the groups of sensory elements which are objectified in this way.

The meaning of an object is in fact always teleological,

finalistic, that is, affective or utilitarian. We understand the meaning of an object only when we know its use. To ask "What is that?" is equivalent to asking "What is that thing used for?" or "Which of our innumerable affective tendencies and of their imperceptible gradations, which of our many and varied wants is this particular thing capable of satisfying or opposing?" And the meaning of the thing consists entirely and solely in the fact that it is a suitable means of opposing or satisfying, whether directly or indirectly, immediately or ultimately, this or that one of our affective tendencies, this or that one of our needs.

In other words, at the very time when a sensory group, made up of a number of elementary sensations, succeeds in awakening or touching off a given affective tendency, either by opposing or by satisfying it, the 'unifying synthesis' of the sensory complex itself takes place, and it acquires at the same time a meaning, which expresses nothing but the satisfactory or the unsatisfactory character of this given affective tendency; it is then and only then that this sensory complex, made over in this manner into a unit, appears also as an object.

That the meaning of things is in general affective or utilitarian or teleological in character, is proved by the fact that at the basis of all common nouns, which denote objects or things, there is always to be found, as a preliminary phase, an *affective classification* of these objects and things. The affective classification of things is a general mental process common to all animals. It is this process, moreover, which makes up and sums up all their 'empirical knowledge.'

Whatever may have been the origin of language, it is certain that the first nouns devised by man were merely *common nouns;* that is, merely phonetic symbols, capable of indicating this or that class of objects, each equivalent in respect to a given affectivity, a given need, a given desire. And this affective character of common nouns has been preserved ever since, and is still preserved today almost intact, although daily use tends to obscure the vivid affective or utilitarian tone which they possessed originally.

Now this affective or utilitarian origin and character of common nouns, the fact that they are nothing but symbols or designations for classes of objects which are equivalent among themselves with respect to one or another of our affective tendencies, or to some one of our needs or desires, demonstrates that the meaning of objects has also the same origin and the same affective or utilitarian character.

To grasp the meaning of an object, is nothing else than to classify it according to its affective character, or from a utilitarian viewpoint—to recognize it as belonging to this or that class which is already known to us from the affective or utilitarian viewpoint.[4]

III. Configuration as Concept

Under the name of 'form' the configurationists also place geometrical concepts, quantitative concepts, and scientific concepts in general, thus increasing the confusion of their theory even on this side.

As regards the concept of 'geometrical figure,' the many difficulties that Locke himself found in trying to form a 'general idea' of *triangle*—"which must be," he says, "neither oblique, nor a rectangle, neither equilateral, equicrural nor scalene, but all and none of these at once"—these difficulties all disappear if we realize that the concept of the triangle is, in the last analysis, nothing but an utilitarian or technical classification of a certain number of geometrical figures, which, while possessing very different forms, nevertheless all exhibit the common trait of being closed figures with three sides only (the least number of sides that a closed rectilinear figure can have) and thus possessing certain geometrical properties which are the same for all. Because of this common trait these figures are all 'equivalent,' when regarded as an instrument of research in certain geometrical investigations. It is, for instance, quite immaterial in measuring the distance between the observer and an inaccessible point, whether we use one form of triangle rather than another.

[4] On these points *cf.* Rignano, E., 'Psychology of Reasoning,' Ch. V; From concrete reasoning to abstract reasoning.

For most geometrical demonstrations, too, the form of triangle or triangles used is entirely immaterial. For example, to find the sum of the internal angles of a polygon, we may divide it as we like into a certain set of triangles or into another set of very different triangles. So too it is quite immaterial to the geodetician or the surveyor, all other conditions being equal, whether he uses one system of triangulation or another.

In other words, just as the concept of 'paper-cutter,' for instance, includes a number of objects which, although differing from one another from the standpoint of perception, are none the less equivalent in respect to the purpose of cutting the pages of a book without tearing it; in the same way the concept of triangle embraces a number of geometrical figures that are very different from the standpoint of perception, but which are equivalent in respect to the ends which the geometrician, the geodetician, the surveyor, and the astronomer seek to attain with this technical instrument.

And just as there does not exist the 'configuration' either of the paper-cutter in general, or of poison in general (the latter being a class of substances that are extremely different, yet equivalent with respect to the destruction of life) but only the 'concept' of one and the other exists, so there does not exist at all the 'form' of the triangle in general, but simply and solely the 'concept' of it.

As regards the quantitative concepts of length, of area, of volume, of force, etc.—which are also included by the configurationists, as we have said, under their ambiguous term 'form'—it is evident that they too have an affective origin and character.

Thus, the earliest quantitative concept of length or distance arose from the comparison of two or more stretches, which might be as different as possible from one another in all other respects, but which were 'equivalent' from the affective standpoint of fatigue, represented in this case by the amount of walking needed to transport one's own body or a certain load from one place to another.

It was the redistribution of cultivable fields to agri-

culturists after the recession of the waters from the Nile inundation, in such fashion that each piece of ground should be 'equivalent' to every other (that is, capable of yielding the same quantity of wheat whatever might be the geometrical form of the field, this being the sole aim of the redistribution) that gave rise, as we know, to the concept of area.

The equivalence of several leather bottles, having extremely different forms, but such that when filled with water they were sufficient to satisfy the thirst of the same number of individuals during the same number of days—this 'equivalence' could not fail to bring about the rapid rise of the concept of capacity or volume.

Similarly the first concept of force arose, very probably, from the 'equivalence' noted between the work of one vigorous man and the work of a number of youngsters in the task of lifting or carrying a huge rock, or felling a great tree, or accomplishing any other similar piece of work. And so forth.

The concepts of these various quantities—lengths, areas, volumes, forces, etc.—arose, then, from the comparison of objects or phenomena that are entirely different, it may be, from the sensory or perceptual viewpoint, but are 'equivalent' with respect to a certain need or a certain desire, which they are called upon to satisfy, or with respect to a certain pain which they arouse.[5]

Now, this affective or utilitarian origin and nature is common also to all scientific concepts in general.

We know, as a matter of fact, that science passed through a primitive phase, during which scientific speculation had for its sole object the classification of phenomena. For example, every somewhat exceptional celestial phenomenon, such as the rainbow, comets, eclipses, unusual conjunctions of planets, etc., was a continual source of superstitious terror or hope; and the speculations of the first astrologers had for their aim simply to classify these phenomena into phe-

[5] *Cf.* Rignano, E., *op. cit.*, 'Psychology of Reasoning,' *cap. cit.*, From concrete reasoning to abstract reasoning.

nomena of good augury and phenomena of ill-omen. Similarly, what ancient Greek science aimed at, as Epicurus expressly declares, was simply to bring new and unknown phenomena into line with more usual and more familiar phenomena for the avowed purpose of thereby *freeing man from the terror* caused by phenomena altogether different from those which they experienced day by day.

We may realize, further, the importance, in a much more recent epoch, of the proof that the much dreaded comets are merely planets with very long elliptical orbits, or of the resolution of the mysterious rainbow into the simple phenomenon of light refraction, or of the explanation of lightning which enables us to class it among phenomena of electrical discharge rather than as a manifestation of divine wrath. And so on.

From this need for an affective classification of phenomena there gradually arose later on the need of knowing the origin of these phenomena. Whenever men did not succeed in classing a phenomenon directly among other more familiar ones, they sought at least to determine whether it did not arise from one of these more familiar phenomena or from some combination of them. *It was in this way that there arose the scientific need for a history of things.*

Now, experiment has demonstrated that, in order that a phenomenon with which we are not yet familiar may be traced back to certain phenomena that *are* familiar, it is not necessary that the latter be in every case completely identical; it is sufficient to establish their identity with respect to merely a few—sometimes but one—attribute or character. This is why certain phenomena, which differed from one another in every other respect, were considered as 'equivalent' *in relation to one end, that of producing the phenomenon to be explained.*

Thus the scientific conceptual classification of concepts, strictly speaking, differs in no essential way from the affective or utilitarian classification in general, since the production of the phenomenon to be explained constituted *the end*, on the basis of which was built up the classification of given

phenomena recognized as 'equivalent' in respect to that end. And this group of phenomena, equivalent in respect to the end in view, formed the very scientific concept required to give the desired explanation.

For example, all bodies, whether solid, liquid, or gaseous, despite the differences which distinguish them in all other sensory aspects, have been grouped by physicists into a single and unique class, as bodies 'having mass,' *because when their masses are equal, these bodies are equivalent in respect to the production of certain phenomena of movement.* And it is due to this 'concept' of mass that certain phenomena, unfamiliar and dreaded, such as the appearance of comets or the unusual conjunction of planets, have been traced back to phenomena of the most familiar sort—to the falling of weights—and classed among phenomena not in the least formidable.[6]

This general affective or utilitarian or teleological character of classification, which we have thus found to lie at the basis of all scientific concepts, enables us to explain the transition from concrete and intuitive reasoning, of which even animals are capable, to abstract and scientific reasoning, to the level of which man alone has been gradually able to lift himself, owing to the continual discovery of new 'equivalences' infinitely numerous among the objects or phenomena which the outer world reveals to him, however different these phenomena may be in every other sensory aspect.

This has enabled us to understand also the greater 'technical yield' of abstract reasoning, compared with concrete reasoning, and to show why the progress of science has consisted in gradually passing to more and more abstract forms, till it has reached the very summit of mathematical reasoning, in its highest forms.[7]

Compared with these results of our theories, what contri-

[6] *Cf.* Rignano, E., 'Psychology of Reasoning,' *cap. cit.*, From concrete reasoning to abstract reasoning.

[7] *Cf.* Rignano, E., *op. cit.*, Ch. V, From concrete reasoning to abstract reasoning; Ch. VI, From intuition to deduction; Chaps. VII and VIII, Mathematical reasoning in its phases of direct and indirect symbolism, of symbolic condensation and symbolic inversion; Ch. IX, Mathematics and mathematical logic.

butions have the configurationists, who confuse *concept* with *form*, made to the solution of these fundamental problems, which are of interest at once to psychology, to logic, and to science in general?

Conclusion

From the above discussion which has necessarily been very concise, it is evident, we believe, that the errors and deficiencies in this theory of form, today so prevalent in Germany, are not of slight importance. The great confusion which prevails in this theory, and which others have already noted, is due to the fact that it has never well defined and explained what is meant by the word 'Gestalt' and that it includes under this term the most disparate psychological phenomena and processes. One often gets the impression that its explanations of complex phenomena and processes consist solely in applying the magical and mysterious name 'form.' Finally the numerous contradictions into which the various representatives of this theory have fallen, both with one another and each with himself on different occasions, make it extremely difficult to form a clear idea of what the theory really means or to discover its central nucleus.

Sometimes it seems like an abortive attempt to return to the Kantian psychology by postulating certain preëstablished *a priori* mental forms which, in the guise of teleologically predisposed and preadapted recipients, gather in and systematize the sensory elements which are furnished by the outer world, thereby giving them the aspect or the meaning which interests us most from the standpoint of the preservation of our existence.

At other times it appears as an attempt, quite opposite to the above, to give a *purely and simply sensorial explanation* to all mental phenomena by means of 'form.' This happens when the latter is considered *as the direct product of the sensations themselves*, and as due to the activity of the transverse connecting nerve currents which arise among and under the impulse of those currents which make up the physiological correlate of the direct sensory excitations, these two together

making up the 'form' itself. This attempt was bound to fail, like all other sensationistic theories, through not realizing that two essentially different factors combine to determine our psychic functioning: sensations and mnemonic sensory reproductions on the one hand, affective tendencies on the other.

In this respect, then, the configuration theory has not succeeded in making good the real and important deficiency in the school of English associationists, who likewise failed to recognize the affective factor, and endeavored to build up the human mind on the basis of sensations alone. Consequently we cannot admit that, in this respect, the form-theory marks any advance over the English association theory. Rather it marks a regression from that theory, since it endeavors, greatly to the detriment of clearness in thinking, to reverse the relations, correctly observed by the English association school, between elementary sensation as a primary datum, and perception, the process of unification and synthesis, as a derivative and secondary datum.

Nevertheless, no one can deny that configurationism has certain undoubted and not unimportant merits: First of all its adherents have striven persistently to demonstrate the need of assuming certain organizing and synthetic processes in order to effect the passage from the multitude of chaotic and fragmentary sensory elements to the actual, comprehensive and unitary mental processes—although the configurationists have not succeeded in throwing light upon these organizing and synthetizing processes, owing to their not having recognized the affective basis of these processes. In the second place—though this concerns only a special point in their theory—they deserve credit for having placed in the foreground the problem of investigating the physiological correlate of the order in which the elementary sensations are arranged, and for having attempted with some success to reach a solution of the problem. In the third place, and most important of all, they have aroused a new zeal for research, first of all in Germany, and later in all other lands. This fervor, if it be guided and enriched by additional

thoughtful consideration and by independent criticism, free from partisanship and from the ambiguities of purely verbal expressions, and if it be directed toward the very root of things, will not fail to give rise again to really fruitful results and to enable psychological science to advance many stages along its upward path.

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THE GESTALT-HYPOTHESIS

BY ROBERT MORRIS OGDEN

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In a recent number of *The American Mercury* our modern gadfly, H. L. Mencken, writes of a certain book on psychology as follows:

> What this book has chiefly to tell us is that the so-called science of psychology is now in chaos, and with no sign that order is soon to be restored. It is hard to find two of its professors who agree, and when the phenomenon is encountered, it usually turns out that one of them is not a psychologist at all, but simply a teacher of psychology. . . . There are psychologists in America who started out with the classical introspective psychology, abandoned two-thirds of it in order to embrace Freudism, then took headers into Behaviorism, and are now inclined toward the Gestalt revelation of Köhler and Koffka. Some say one thing and some another. It is hard for the layman to keep his head in this whirl.[1]

Despite the reassuring words of Knight Dunlap in his article on 'The Use and Abuse of Abstractions in Psychology,'[2] most psychologists will agree that there is some truth in what Mencken says. Not only is it 'hard for the layman to keep his head,' but the progress of psychology as a science is suffering for want of agreement concerning both its facts and its postulates. Psychological facts can be stated only with reference to the conditions under which they were obtained; and this reference includes a 'point of view' which is based upon theoretical postulates. At present, the divergence among these postulates is so great that what may pass for facts under one set of postulates is called fiction under another set. The purpose of this paper is to support the claims of what Mencken calls 'the Gestalt revelation' as a means of reconciliation for the opposite views and results

[1] *The American Mercury*, 1927, 11, pp. 382*f*.

[2] *Phil. Rev.*, 1927, 36, pp. 462*ff*.

of introspectionists, functionalists, behaviorists, and other psychologists.

The acceptance of the Gestalt-hypothesis requires a radical departure from the time-honored analytic method of scientific procedure; but this departure is calculated to resolve our psychological difficulties, and at the same time to place psychology in a definite coöperative relationship with the other sciences. In order to achieve these ends, the hypothesis must embrace all science; and, in so doing, it must imply a philosophy, the details of which have yet to be worked out. It is not surprising that many scientists should hesitate in accepting these broad claims of the Gestalt-hypothesis, especially for fear of becoming involved in epistemological controversy, and the espousal of a half-baked philosophy.

The question concerning the basis of knowledge which is thus raised is, however, inescapable. While the so-called 'natural' scientist may try to escape it, the psychologist is less able to do so. The more or less successful evasion of the issue by the 'natural' scientist depends upon the fact that he is dealing largely with ponderables upon which he can experiment and achieve definite results without resting so heavily upon variable postulates and 'points of view' as the psychologist must. Nevertheless, all science rests upon postulates, and though these postulates are sometimes neglected, they are by no means negligible, as the continued controversies over such things as the ether, space-time, heredity and environment will testify.

The Gestalt-hypothesis, with its radical dismissal of all elemental entities as *reals*, profoundly alters our view of the universe; but it does not deny the validity of experimental methods of analysis. What it does is to put these methods of analysis where they properly belong in the armory of tools and technical devices, while it denies the right to identify moments of measurement with the reality which these tools and devices are measuring.

Gestalt-psychology reinterprets the structural elements, attributes, and dimensions of introspective psychology as

aspects of perceived wholes. Many of these aspects will retain the qualities previously ascribed to them; but they can no longer be regarded in point to point correspondence with specific physical stimuli, and specific physiological responses. Instead, they become formal aspects of a processual pattern, at once physical, biological, and psychological, with the very important addition of a background or field which surrounds and conditions each of these three specialized formulations.

The Gestalt-hypothesis agrees with behaviorism in regarding the perceptual basis of psychology as the response of the whole organism to a situation. But whereas the behaviorist, in an effort to free himself from the privacy of consciousness and the mysticism of purposive control, insists upon a sharp line of demarcation between situation and response, the proponent of Gestalt finds in perception a pattern of behavior wherein both situation and response are participating members. Furthermore, in his description of behavior the Gestalt-psychologist declines to be deprived of the use of those introspective terms which are the means of description in every realm of science.

As a specific element of consciousness my *redness* and yours may be eternally separate, but as a 'gradient' of perceived behavior the redness of a form can have as much objectivity as any other descriptive aspect. To refuse to make use of it because redness has sometimes been abstracted as a simple element or attribute of my personal sense of vision is as foolish as it would be to regard the vaporization of gasoline as a unique and private concern of the particular gas-engine in which it occurs. The lengths to which a behaviorist will go in avoiding the use of terms such as *sensation*, *thought*, and *feeling* are only warranted by the assumption that conscious phenomena are entities in the private possession of individual persons. Similarly, the reduction of behavior to a machine-like order of discrete events, is attributable to a wariness of accepting a mysterious guide which causes a living creature to work in certain ways in order to attain certain ends.

Both these difficulties are swept aside as soon as one questions the validity of separate entities of whatever sort, and substitutes therefor the dynamic pattern of perception as the point of departure in all scientific pursuits. For a dynamic pattern is a self-completing, objective, event, the subjective aspects of which have significance only in so far as they describe its objective nature. The 'purpose' of such an event is not attributable to an external agency, as if the pattern was first of all composed of unpatterned parts. Instead, the 'purpose of things' is inherent in the things themselves, because of a natural inertia which makes them, by virtue of their organization, stay as they are put, or proceed on their respective ways. According to the Gestalt-hypothesis, the principle of organization is not that of an aggregation of entities, but that of a differentiation and assimilation of forms.

Under this treatment the 'conscious contents' of the introspectionist, the 'mental activities' of the functionalist, and the 'neurological tautologies' of the behaviorist all disappear. They are immediately replaced, however, by moments truly descriptive of the total and partial organizations which are under investigation. Thus, *redness* is no longer a constituent part of perception, but an outstanding moment in a certain event—a moment which becomes significant whenever the event in question changes with its degree of redness. Since primary importance attaches to the event, we have no need for abstracting *redness* and treating it as though it were a 'content.' Although our ability to do so is sometimes called a talent for psychologizing, the behaviorist is quite right in challenging the scientific value of any such procedure. Yet even if we may question the significance of an abstract realm of purely psychological 'contents,' we have no reason to deny the validity of color, for instance, as a descriptive term; indeed, color may be quite as important to a psychologist as it is to a spectroscopist.

In accordance with the Gestalt-hypothesis, the particular mental activities of the functionalist also suffer a 'sea-change.' Being concerned with a description of events 'in the round,'

we no longer need to draw hard and fast lines between the *experienced*, the *experiencing*, and the *experiencer*. An event may have a beginning and an end, subjective and objective aspects, static and dynamic moments. All these can be studied in terms of functions, structural relations, and egocentricity. What we cannot do with impunity is to analyze an event into its constituent functions, any more than we can analyze it into its constituent parts. Instead, we must take each moment for what it is, namely, an aspect of an unanalyzable whole.

As regards the behaviorist's method of analysis, it is likewise objectionable when he insists upon building up his patterns of behavior from part-movements. No movement is made up of parts, as Zeno showed ages ago, and there is no point to point correspondence between situation and response. But the dynamic course of an act of behavior leads to the study of its physiology and its physical conditions, as well as to its psychological moments. The Gestalt-hypothesis is radical in its refusal to regard anything as built up from an aggregate of parts. It therefore makes little of the virtues that are sometimes ascribed to structural analysis, functional classification, and the conditioning of responses by discrete stimulation. But the impossibility of reconciliation between introspective, functional, and behavioristic psychology is so obvious that one may well question if the foundations of all three are not somehow faulty.

The Gestalt-hypothesis is based upon a foundation different from any of these other theories; for it invites us to regard form and pattern not as an accretion but as the essence of reality. With this postulate we find that we have set aside all the major objections which the various other schools of psychology have been prone to raise against each other. Since the Gestalt-hypothesis can be employed by the introspectionist, the functionalist, and the behaviorist, it would appear that for this reason alone the psychologist should welcome an opportunity to re-envisage the results of his previous labors in an effort to discover, if he can, certain principles of investigation upon which all may agree.

According to the Gestalt-hypothesis, the subject of scientific inquiry is not something to be dealt with from a variety of different points of view, subject only to an eventual correlation. Instead, there is but one scientific point of view, and it is applicable to everything. While this single point of view surveys the many methods which constitute the various special sciences, all these methods have a common origin in perception, and therefore a generic relationship with one another. Consequently, the Gestalt-hypothesis embraces all the sciences, and points to a philosophy that is calculated to answer all fundamental questions.

In conclusion, I would emphasize the hypothetical character of this 'revelation'—new, yet old, for most of its theory can be read in the pages of Plato and Aristotle. While a Gestalt-theory promises much, we have as yet only a working hypothesis, the results of which in promoting scientific investigation on firm foundations lie chiefly in the future. At present, it is only as a fruitful guide in research and in the interpretation of research that the 'Gestalt revelation' bids fair to merit the term coined for it in derision by H. L. Mencken.

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A LEARNING CURVE EQUATION AS FITTED TO LEARNING RECORDS[1]

BY M. C. BARLOW
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A much neglected, but important, approach to the measurement of intelligence is the study of individual learning records. In the past, intelligence measures have consisted, in large part, of composite scores of numerous achievement tests. The delayed development of measuring intelligence by learning methods is at least partially due to the practical difficulties involved in perfecting an acceptable technique for treating learning scores. Lack of test material suitable for continued practice in special mental traits has been partly responsible for the slow development of measures of learning ability. Before marked progress can be made in this field of investigation we must have more tests which employ learning of various degrees of difficulty. The training on such material should extend over a considerable number of working periods.

Our task is to investigate individual learning records made from continued practice in mental multiplication. It involves the following problems: (1) to find a suitable equation in terms of the two primary variables of the learning process, namely, practice and achievement, (2) to compare different methods of fitting an equation to the data of the learning process, (3) to determine how well the final achievement can be predicted from the first half of the learning records, and (4) to determine the relations between the constants of the fitted equation and ability in arithmetic as measured by final achievement in mental multiplication.

Before extensive use can be made of equations as a means of representing the results of individual learning, curve fitting for such studies should be rescued from the field of art and

[1] From the Psychological Laboratory of the University of Chicago.

made available for science. The success enjoyed by graphical and inspectional methods of finding parameters in the physical sciences is probably due to low irregularity within the observed variables. In psychological work, however, there is usually found high irregularity among learning scores. Consequently graphic methods which depend on inspection of the plotted data are subject to considerable variation. It is quite likely that an investigator would obtain by these methods very different parameters on different occasions, and also that several persons would not get the same parameters from the same data by these methods. The amount of difference would depend largely on the variability of the scores themselves, on the number of scores available for calculation, and on the degree of curvature represented by the plot. If the learning curve represents the average performance of a group in successive periods of practice, the curve will be continuous and it may show no inversions of the first or even of the second order. For such group learning curves, the graphic method of determining the parameters gives satisfactory results. The graphic or inspection methods are unsatisfactory, however, when the object is to fit an equation to the learning data for a single subject.

The above mentioned difficulties are due partly to the inherent irregularity of the individual learning records themselves and partly to the unpredictable variations of the observer in curve fitting by inspection. It is this latter type of variation which can be eliminated by the adoption of a straightforward and routinized procedure for calculating the parameters. Several investigators would then necessarily obtain the same parameters from the same set of data, but while such uniformity of recommended procedure results in a certain convenience it does not, of course, remove the unreliability of the parameters which is inherent in the irregularities of the original data. To express the degree of confidence to be attached to the parameters would require the separate calculation of their probable errors.

A learning curve is commonly defined as the graph connecting points which are determined by plotting a set of two

variables, namely, practice and achievement. Relatively large absolute gains made by learners during early practices give to the graph its steep initial ascent. In a practice curve the period of large gains is followed by one of smaller gains. Gains decrease rapidly in later practices causing the curve to bend sharply as it approaches a horizontal slope. When the learning curve is widely extended its limiting ordinates are measurements of the highest level of actual achievement. This level of the curve is known as a practical physiological limit of training in the mental trait being measured.

The particular form of the curve of learning is influenced by the size of units used in the graph. Suppose a to be the unit of linear measure that represents a unit response for each of two pairs of variables, namely, practice and achievement. If a stands on the Y axis for a small mental output and at the same time stands on the X axis for a large practice amount, the curve will usually rise abruptly and flatten out rapidly. Reversing the order of magnitude of the responses as represented by one spatial unit on the two axes, makes the resulting curve ascend slowly and approach the horizontal gradually. If we obtain two series of magnitudes measuring practice and progress and plot them, and if we represent $2n$ the X units spatially by 2 mm. and n of the Y units by 2 mm. we get the first mentioned curve, but if we represent $3n$ of the Y units by 2 mm. we get the second curve form.

The graph of the time-work units (time required to complete constant work units) is a falling curve of positive acceleration. The above mentioned forms of the learning curve, and there are also many other possible ones, can all represent the same learning data. The form of the curve of learning depends upon (1) the relative size of the practice units and the progress units which correspond to the unit of spatial measurement on the graph, and (2) upon the relative size of the spatial units on the X and the Y axes of the graph.

An essential feature of equations of the learning function is the faithfulness with which they represent the learning scores. The writer knows of no single equation capable of fitting many different types of learning curve forms. In

trying out different equations, trial applications were made of these equations upon a variety of curve forms. The two forms found to have greatest flexibility are the simple hyperbola and the simple exponential equations, the first of which is to be considered here.

Of the few studies that have been made of learning curves, Thurstone's [2] work on the learning curve equation was probably the first effort in fitting the hyperbolic equation to learning curve forms. This equation was selected by him as furnishing the most satisfactory representation of typewriting learning. In solving for its constants Thurstone read one of them directly from the raw data. As stated above, this method can be used satisfactorily only with scores that have a high degree of uniformity.

In the equation

$$Y = \frac{LX}{X + R}$$

the R is defined by Thurstone as the 'rate of learning.' It corresponds to the A in the hyperbolic expression introduced later. The R's as calculated for individual learners when compared with predicted final achievement in typewriting, yield a correlation coefficient of .75.[3]

In the 'Equation of the Learning Function,' by Meyer,[4] objection is made to Thurstone's procedure on the grounds that it is not based upon sufficiently rational considerations. Meyer affirms that the second constant, R, in Thurstone's equations and called by him the 'rate of learning' is, on account of the name chosen, a confusing and irrational definition. R, he continues, 'could be defined as the reciprocal value of individual learning ability.' It is not shown, however, how this reciprocal, which in reality is the reciprocal of Thurstone's definition of rate of learning, can be more rational than the R as defined by Thurstone.

[2] Thurstone, L. L., 'The Learning Curve Equation,' PSYCHOL. MONOG., 1919, **26**, No. 114.

[3] Thurstone, L. L., 'The Learning Curve Equation,' PSYCHOL. MONOG., 1919, **26**, No. 114, p. 33.

[4] Meyer, M. F., and Eppright, 'The Equation of the Learning Function,' *Amer. J. Psychol.*, 1923, **34**, pp. 203–222.

The equation offered by Meyer is a trigonometric function of the form

$$t = T + K \text{ arc cot } (n + p),$$

in which T, K and p are constants with variables t and n. In finding appropriate numerical values for the constants, the investigator guesses at p and K until a satisfactory value is found for T. If the degree of dependency of learning curve equations upon empirical measurements for the evaluation of their constants is taken for a criterion of the degree of rationalism in the equation, then Thurstone's equation is the more rational for his method requires empirical measurement of only one constant.

The value of different equations as a means of representing learning data can be determined only from the effectiveness with which they deal with problems of learning. One feature not to be overlooked is the facility with which they can be applied to the raw data to be considered. Another is the uniformity of results of curve fitting that follow from the same data, as handled by different individuals.

Turning to the hyperbolic equation

$$Y = \frac{LX}{X + A} \tag{1}$$

we find the constants readily definable. In its rational form X and Y are commonly the two unknown variables, but, from the empirical viewpoint, having given the coördinates of the points they become the known values and the problem is to find the numerical values of the constants. Hence, values corresponding to X and Y are known while those corresponding to A and L are unknown. The sign of A is always negative for positively accelerated curves but positive in curves of negative acceleration. The limit of the asymptote Y in equation 1 equals L when X becomes infinite, as shown by evaluating[5] equation 1 which is indeterminate with $X = \infty$

$$Y = \frac{LX}{X + A}\Bigg]_{\substack{\text{limit} \\ X \to \infty}} = L$$

[5] Granville, W. A., 'Elements of Differential and Integral Calculus,' p. 172.

and similarly

$$X = \frac{-AY}{Y-L}\Bigg]_{\substack{\text{limit} \\ Y \to \infty}} = -A.$$

In the case of empirical equations there are two methods of solving for the constants which depend upon the data being in rectified form. One is the method of inspection; the other, the method of averages. Data are said to be in rectified form when the coördinates of their plotted variables approach linearity. Non-linear plots of gross scores often become linear when the variables are plotted as determined by the constants of an appropriate equation which is stated in linear form.

Method of Inspection

The form

$$Y = \frac{LX}{X-A} \tag{2}$$

becomes linear in the form

$$X = A + L\frac{X}{Y}. \tag{3}$$

X is the total number of work-units completed. Y is the number of minutes to complete one work-unit with X units of practice. If the graph of variables X/Y and X approximates a straight line, equation (2) will represent the form of the learning curve.

The illustrative example contains scores made by an individual in continued practice of mental multiplication. The subject worked sixteen minutes daily until a total of more than sixteen hundred examples had been finished. The X variable is the total number of practice units, the unit of work is sixty-three examples made up of two numbers with two digits each. The Y variable is the number of minutes required to do successive work-units. In order that the initial observed variables may fall on the origins of the X and the Y axes, the empirical X's are each decreased by 1, making

$$X = X_1 - 1 \tag{4}$$

X_1 is the observed X; X is the corrected X.

The constants of the hyperbolic equation fitting these data are found by the method of inspection from the scores in the X and the Y columns of Table I. The X's are restated according to equation (4). The X/Y column contains quotients derived from corresponding X's and Y's. The plot of X and X/Y gives the straight line of Diagram 1, hence equation (2) is usable in fitting the given data.

TABLE I

TABLE OF DATA FOR FITTING CURVES TO MULTIPLICATION SCORES

X	Y	X/Y	Y_1	R_1	Y_2	R_2	Y_3	R_3
0.....	23.0	0						
1.....	15.0	.063					32.07	
2.....	12.0	.167	19.32	7.32	16.84	4.84	14.41	2.41
3.....	13.5	.222	14.12	.62	13.17	− .33	12.18	− 1.32
4.....	11.0	.364	12.44	1.44	11.88	.88	11.30	.30
5.....	13.5	.370	11.62	− 1.88	11.22	− 2.28	10.83	− 2.67
6.....	11.5	.522	11.12	− .38	10.82	− .68	10.54	− .96
7.....	11.5	.609	10.80	− .70	10.55	− .95	10.34	− 1.16
8.....	11.0	.727	10.56	− .44	10.35	− .65	10.20	− .80
9.....	10.5	.857	10.39	.11	10.21	− .29	10.09	− .41
10.....	9.5	1.042	10.24	.74	10.09	.59	10.01	.51
11.....	11.0	1.000	10.14	− .86	10.00	− 1.00	9.94	− 1.06
12.....	9.5	1.264	10.06	.56	9.93	.43	9.88	.38
13.....	10.5	1.238	9.98	− .52	9.87	− .63	9.83	− .67
14.....	10.0	1.400	9.92	− .08	9.81	− .29	9.79	− .21
15.....	10.5	1.428	9.87	− .63	9.77	− .73	9.76	− .74
16.....	10.0	1.600	9.82	− .18	9.73	− .27	9.73	− .27
17.....	10.0	1.700	9.78	− .22	9.69	− .31	9.70	− .30
18.....	10.0	1.800	9.74	− .26	9.66	− .34	9.68	− .32
19.....	9.0	1.111	9.71	.71	9.64	.64	9.66	.66
20.....	9.5	2.105	9.68	.18	9.61	.11	9.64	.14
21.....	9.5	2.210	9.66	.16	9.59	.09	9.62	.12
22.....	9.0	2.444	9.64	.64	9.57	.57	9.61	.61
23.....	9.5	2.421	9.61	.11	9.55	.05	9.59	.09
24.....	9.5	2.527	9.60	.10	9.54	.04	9.58	.08
25.....	9.5	2.632	9.58	.08	9.52	.02	9.57	.07

X: gross time scores; Y_1: inspection method scores; R_1: Y_1 residuals.
Y: total practice amount; Y_2: scores by averages; R_2: Y_2 residuals.
X/Y: rectifying quotients; Y_3: scores by least square method; R_3: Y_3 residuals.

From the equation it is seen that the Y intercept is A and the slope of the linear graph is L. As measured graphically, $L = 9.18$ and $A = 1.05$. Placing them in equation (2) gives

$$Y = \frac{9.18X}{X - 1.05}.$$

From this form the scores in X are calculated as in Column Y_1 in Table I. Calculated scores corresponding to $X = 0$ and $X = 1$, give 0 in the first case and a negative value in the second.

These are omitted from the table for the reason that they are useless for our purposes. There is a fairly close agreement of the real scores and the calculated ones. The larger

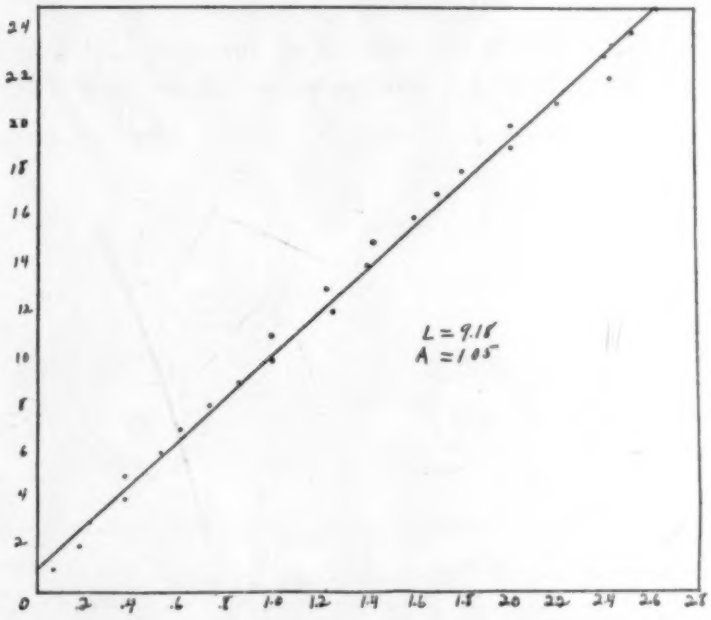

DIAGRAM 1. Graph yielding learning curve constants from rectified learning scores with total practice, X, as ordinates and linear slope constants, X/Y, as abscissæ.

residuals occur in connection with the early scores. The mean residuals, R, with work-units 1 and 2 omitted, is .788 minutes; of the first 5 used scores it is 2.33 minutes; for the last 5 scores, .22.

The above procedure may be summarized as follows:

1. Express the equation in linear form.

2. Arrange the two sets of independent variables in two columns and calculate the X/Y quotients.

3. Plot the paired values X/Y, X. The equation will represent the data only upon the condition that their plot approximates a straight line.

4. The additive constant, A, is the Y intercept read directly from the graph.

5. The slope constant or the slope of the line of relation is defined as $L = (Y - A)/X$ in which $(Y - A)$ is taken relatively large.

Method of Averages

To make use of the method of averages, which is the second way of finding constants, we divide the data of the X

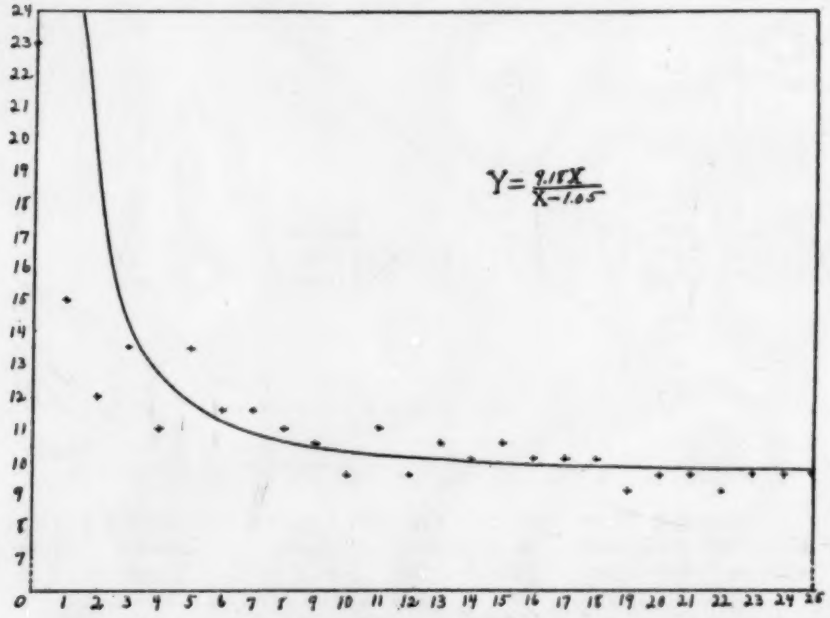

Diagram 2. Graph of learning scores as calculated from the hyperbolic equation with constants found by graphical method.

and Y variables into two parts—equal parts if there is an even number of scores in each variable—and substitute the proper sums in the two following equations:

$$SX = NA + LS\frac{X}{Y}, \tag{5}$$

$$SX_1 = N_1A + LS\frac{X_1}{Y_1}. \tag{6}$$

S indicates summation. N is the number of items in the first part of the data. N_1 is the number of items in the second part of the same set of data. Taking N and N_1 equal to 13 and

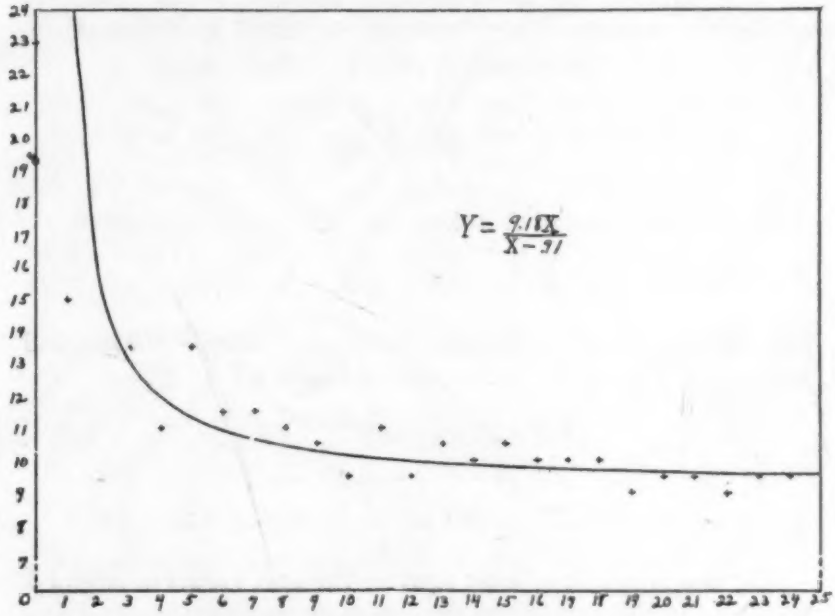

DIAGRAM 3. Graph of learning scores as calculated from the hyperbolic equation with constants found by the method of averages.

solving in equations (5) and (6) gives the numerical value of the A constant, .91, and L, 9.18. The resulting equation is

$$Y = \frac{9.18X}{X - .91}.$$

The scores as calculated appear in column Y_2 of Table I. It is seen from Diagram 3 that they closely approximate the real scores. The residuals as contained in the R_2 column have a mean value of .708 minutes, the mean of the first 5 is 1.80, and of the last 5, .15 minutes.

It is to be remembered that the method of averages can be used to determine the constants only if X and X/Y values show a linear plot. If this condition is satisfied, the constants come out directly from dividing the data into two parts and substituting appropriate values in forms (5) and (6) of the hyperbola.

Method of Least Squares

The method of least squares presented here may be expanded to include any number of variables. Let X_1Y_1, $X_2Y_2 \cdots X_nY_n$ be numerical values of observations in

$$Y = \frac{LX}{X - A}$$

with constants A and L unknown. This may be written

$$XY - AY - LX = 0.$$

Substituting the observations in the foregoing equation and letting $V_1, V_2 \cdots V_n$ be the residual errors,

$$\begin{aligned} X_1Y_1 - AY_1 - LX_1 &= V_1, \\ X_2Y - AY_2 - LX_2 &= V_2, \\ X_nY_n - AY_n - LX_n &= V_n. \end{aligned}$$

By the principle of least squares the best values of A and L result when the sum of the squares of the residual errors V is a minimum

$$V^2 = V_1^2 + V_2^2 + \cdots V_n^2$$

$V^2 = f(A, L)$ and a necessary condition that it shall be a minimum is that the first differential coefficient of each equation shall be 0.

Placing these equal to 0 and solving for A and L give critical values of the variable which might be investigated for maxima and minima but it is not necessary since it will appear from the experimental data obtained later that we have a minima.

Applying this condition to the above equations, we have

$$\frac{d}{dA}V^2 = \frac{d}{dA}(V_1^2 + V_2^2 + \cdots + V_n)$$
$$= 2(V_1\frac{d}{dA}V_1 + V_2\frac{d}{dA}V_2 + \cdots + V_n\frac{d}{dA}V_n) = 0,$$

$$\frac{d}{dL}V^2 = \frac{d}{dL}(V_1^2 + V_2^2 + \cdots + V_n)$$
$$= 2(V_1\frac{d}{dL}V_1 + V_2\frac{d}{dL}V_2 + \cdots + V_n\frac{d}{dL}V_n) = 0.$$

Substituting the values of V_1, V_2 and writing the partial differentials indicated in the foregoing equations, gives

$$(X_1Y_1 - AY_1 - LX_1)Y_1 + (X_2Y_2 - AY_2 - LX_2)Y_2 + \cdots + (X_nY_n - AY_n - LX_n)Y_n = 0,$$
$$(X_1Y_1 - AY_1 - LX_1)X_1 + (X_2Y_2 - AY_2 - LX_2)X_2 + \cdots + (X_nY_n - AY_n - LX_n)X_n = 0.$$

Expanding these two equations, summing similar terms and substituting X, Y for X_1, Y_1 and X_2, Y_2,

$$\Sigma XY^2 - A\Sigma Y^2 - L\Sigma XY = 0, \tag{7}$$
$$\Sigma X^2Y - A\Sigma XY - L\Sigma X^2 = 0. \tag{8}$$

Equations (7) and (8) which are in reality normal equations can be obtained more directly from the fundamental form

$$Y = \frac{LX}{X - A}.$$

The rectified form is

$$AY + LX - XY = 0.$$

The observation equations of the rectified form are

$$A_1Y + L_1X - XY = 0,$$
$$A_2Y + L_2X - XY = 0.$$

Then the normal equations follow by the rules found in textbook on Least Squares.[6]

[6] Rietz, H. L., 'Handbook of Mathematical Statistics,' p. 66.

Normal equation for A: $A_1\Sigma Y^2 + L_1\Sigma XY - \Sigma XY^2 = 0$;

Normal equation for L: $A_2\Sigma XY + L_2\Sigma X^2 - \Sigma X^2Y = 0$.

Replacing A_1, A_2, L_1, L_2 by A and L, for they are values of the constants A and L, gives

$$A\Sigma Y^2 + L\Sigma XY - \Sigma XY^2 = 0,$$
$$A\Sigma XY + L\Sigma X^2 - \Sigma X^2Y = 0,$$

which are identical with equations (6) and (7) above.

Multiplying (7) by $\Sigma Y^2/\Sigma XY$ and solving the resulting simultaneous equations,

$$L = \frac{\Sigma Y^2(\Sigma X^2Y) - (\Sigma XY)(\Sigma XY^2)}{\Sigma Y^2(\Sigma X^2) - (\Sigma XY)^2}, \tag{9}$$

$$A = \frac{\Sigma X^2Y - L\Sigma X^2}{\Sigma XY}. \tag{10}$$

Example: To make use of the method of least squares in representing a set of learning data by an equation of the form

$$Y = \frac{LX}{X - A}.$$

1. Arrange the X, Y variables in serial order, remembering the corrected X is less by 1 than is the empirical X, and calculate a column each in X^2, XY^2, X^2Y, and Y^2.

2. From the columns thus obtained, secure the proper sums required for substitution in the given equations containing the learning curve constants.

3. Substitute these values in equations 9 and 10, and solve for L and A.

4. Calculate, by means of equation 1, the time-scores, Y, corresponding to certain magnitudes of practice, X.

In Table I, X and Y columns are original data used in the first two methods of solving for the constants. The magnitude of X^2, XY, X^2Y, XY^2, and Y^2 are obtained from X and Y. Substituting in formulas (9) and (10), we get L and A directly.

$$L = \frac{3415.5(53695.5) - 3239.5(32558.7)}{3415.5(5525) - (3239.5)^2} = 9.30,$$

$$A = \frac{53695.5 - 9.30(5525)}{3239.5} = .71.$$

Putting the numerical values of A and L in (2), we get

$$Y = \frac{9.30X}{X - .71}.$$

The scores as calculated are contained in Table I, Y_3, and their graph is in Diagram 4. The mean difference between the observed and the calculated scores is .677 minutes; for the first 5 scores it is 1.53; and for the last 5, .19.

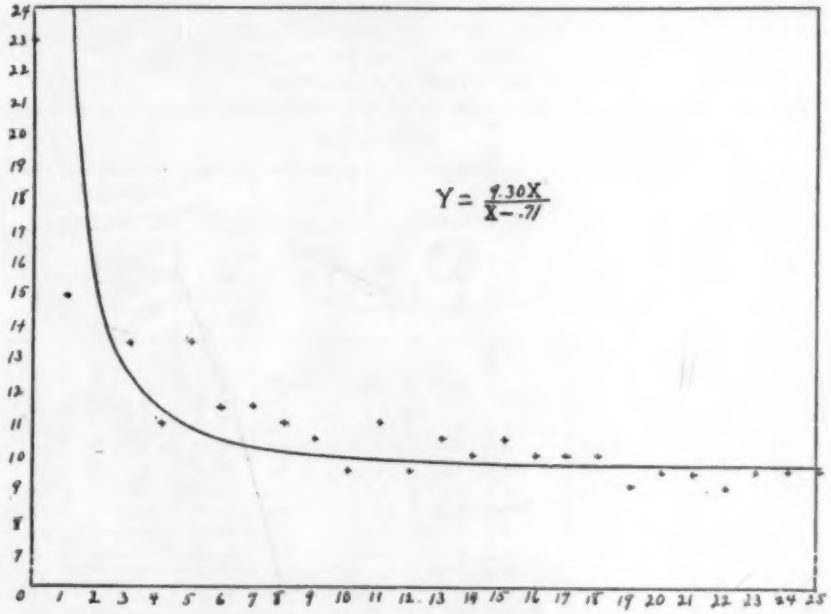

DIAGRAM 4. Curve of learning scores as calculated from the hyperbolic equation whose constants were determined by the least square method.

Obviously, uniform individual learning data can be fitted more precisely by hyperbolic equations whose constants are found by the least square method. The mean values of the residuals are less, with one exception, when the derived scores are obtained by the least square method than when they are determined by either of the other methods. This is taking the methods of inspection and of averages at their best.

If more residuals than those from the one subject in this

study were available, in all probability those residuals resulting from the scores as calculated from the equation which is determined by the least square method would be smaller than the residuals following from the equations found by the methods described above. This is to be expected from the fact that the least square method contains the assumption that the sum of the residual errors shall be a minimum.

TABLE II

SYLLABLES RECALLED AND TOTAL SYLLABLES PRESENTED (LEARNING TIME) OF LISTS CONTAINING 12, 15, AND 18 NONSENSE SYLLABLES. SYLLABLES RECALLED AS CALCULATED FROM THE GROSS SCORES BY MEANS OF THE HYPERBOLIC EQUATION

Syllables Presented	Syllable List								
	12			15			18		
	Syllables Recalled	Calculated Recall	Residuals	Syllables Recalled	Calculated Recall	Residuals	Syllables Recalled	Calculated Recall	Residuals
11.....	3.00	2.60	− .40						
14.....				3.00	2.44	− .56			
17.....							2.00	2.52	.52
25.....	4.75	4.88	.13	4.20	4.04	− .16	3.20	3.57	.37
50.....	7.00	7.19	.19	6.50	6.66	.16	6.25	6.26	.01
75.....	8.60	8.48	− .12	8.45	8.45	.00	8.30	8.28	− .02
100.....	9.35	9.31	− .04	9.50	9.74	.24	9.75	9.84	.09
125.....	9.60	9.89	.29	10.50	10.71	.21	11.10	11.11	.01
150.....	10.30	10.33	.03	11.30	11.47	.17	12.10	12.14	.04
175.....	10.70	10.65	− .05	12.25	12.09	− .16	13.00	13.00	.00
200.....	10.80	10.87	.07	12.75	12.59	− .16	13.60	13.73	.13
225.....	11.20	11.12	− .08	13.25	13.02	− .23	14.50	14.35	− .15
250.....	11.35	11.29	− .06	13.35	13.38	.03	15.25	14.89	− .36
275.....	11.45	11.44	− .01	13.60	13.69	.09	15.30	15.39	.09
300.....				13.90	13.95	.05	15.60	15.78	.18

We shall now give the results of fitting the same hyperbolic equation to data possessing a high degree of uniformity. The raw scores of Table II. are taken from curves by Robinson and Heron [7] representing the absolute number of syllables recalled, or anticipated, and the absolute learning time. The unit for the latter is a single presentation of one syllable. The

[7] Robinson, E. S., and Heron, W. T., 'Studies in Memorization,' J. EXPER. PSYCHOL., 1922, 4, pp. 432–433.

nonsense material was presented in lists of 12, 15, and 18 syllables each. The average numbers of syllables recalled are read graphically for the successive totals of syllables presented.

These results, which possess more regularity than do individual scores, are capable of fitting nicely the learning curve equation. The least square method for the first list gives $A = 40.50$ and $L = 13.13$; for the second list, $A = 81.69$ and $L = 17.76$; and the third list, $A = 12.7$ and $L = 22.49$. The resulting equations and graphs are plotted in Diagram 5. The residuals, as shown in Table II., indicate a surprisingly

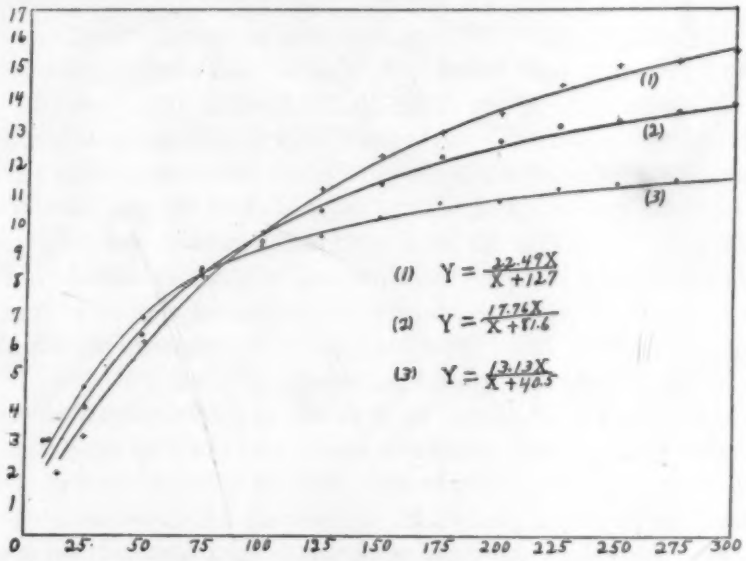

DIAGRAM 5. Showing number of syllables recalled, Y, as against learning time, X, for lists of 12, 15, and 18 nonsense syllables. Data fitted by hyperbolic learning curve equation with constants found by least square method.

close agreement between the true scores and those calculated from the equation. The mean residual for the 12 syllable list is .12; the mean of the first 5 measurements is .18; and of the final 5, .05. The mean residual for the list of 15 syllables is .16; for the first 5, .22; and of the last 5 it is .13. The corresponding residuals for the 18 syllable list are .15, .20, and .18.

In the light of the foregoing data that have been found to

conform quite closely to the forms of the hyperbolic graphs, it is obvious that multiplication and syllable learning, at least, follow the hyperbolic law. It is suggested that experimental results that are in such close agreement with such learning curve forms might be reported in psychological publications in equation form, reserving the space thus saved for the publication of more raw data.

A problem of practical interest in connection with curve fitting lies in the prediction of learning scores beyond the limit of practice represented in the fitted learning data. With learning functions following the hyperbolic law, results in the early training of particular traits become the basis of approximating late excellence without the subjects actually training so as to reach those higher levels. This method of procedure constitutes technique which makes possible an analysis of individual training limits in various mental habits.

In the results given below, records made by pupils taking continued practice in mental multiplication are used to predict on the basis of the first half of practice what might happen if progress continued according to the way it did during the first half. This prediction is compared with what actually did happen as practice continued.

One hundred 14- and 15-year old subjects, distributed in grades 7 to 11, took 16 minute daily practices for 25 periods, or until they completed 1638 examples made up of two numbers of two digits each (digits 0 and 1 excluded). The scores are taken in time-work units (number of minutes required to work 63 examples) and total practice amount (total number of work units completed). Hyperbolic equations are written for the first half of the learning scores belonging to each individual as in the above mentioned units. Calculations are made from these equations of scores which approximate efficiency at the end of the second half of practice. The inter-correlation coefficients define the general agreements as between the actual scores, and the learning curve equation constants.

When the means of the three initial multiplication scores are correlated with the means of the three final scores, the

coefficient is .83 ± .02. This relation implies that the subjects who make high scores during the early practices also make high final scores. It also suggests that the scores made during the early practices on learning material are valuable criteria of final achievement.

The means of the three final scores of the first half of the total practice amount, when correlated with the actual final scores yield a coefficient of .91 ± .01. It shows that students with a low mean score also make low final scores. The mean scores for the entire practice are found to correlate with final scores to the extent of .90.

The A constants (defined by Thurstone as the rate of learning, but defined here as the value of X in the learning curve with Y infinite) correlate with final scores to the extent of .14 ± .07. The additive constants are seen to have little relation to final achievement when practice continues so as to approach a practical limit of training.

The relation between the L constants of the hyperbolic equations and the final scores is represented by a correlation coefficient of .93 ± .01. The highest other predicting coefficient is .91, the next highest, .90. This means that by utilizing the learning curve equation constants as derived from the first half of the total practice, the final ability in multiplication can be more accurately predicted than it can from the means of the first three scores, the means of the last three scores of the first half of practice, the means of the first half of the practice, or the mean total scores.

There is no point to be gained by attempting to validate the results which we claim to be better for the least square method than for either of the other two methods in the foregoing procedure, because of the few cases involved. The investigator made several unsuccessful trials at fitting highly variable learning records by inspection methods. The results from two successive trials were contradictory. As we have used the method of averages and the method of least squares on only one set of data, we are able to say that the latter method gives smaller residuals than does the former. Moreover, the latter method is better from a theoretical standpoint,

since it relies upon the theory that the sum of the residuals equals 0.

Summarizing results, we have confirmed the fact that hyperbolic equations furnish a reasonably satisfactory fit to the form of the learning curve. An hyperbolic equation has been fitted to the same set of learning scores by three different methods, each of which yields the necessary constants by following outlined procedure. The constants are found directly by the least square method from solving two simple equations after substituting particular values which follow easily from the gross scores. This method is to be preferred over the other two because of its simplicity, directness, and for its better calculated scores. Scores of small gross irregularities give better results in curve fitting than do those of high variability.

Predicted limits of training correlate more highly with practical training limits than do any other values used as scores in this investigation. The additive constants are of little value as a means of predicting final practice achievement. Finally, while the learning curve forms under consideration fail to show exact agreement with the forms of the learning curve equation, there is sufficient similarity between them to justify the use of the latter for representing the former in certain mental traits, as multiplication and syllable learning, and for predicting limiting practice achievements from the results of early practice in those traits. Further work is necessary to determine more fully the value of the hyperbolic equation as a means of predicting learning attainment beyond actual practice.

[MS. received July 6, 1927.]

INSTINCT AND INTELLIGENCE

BY MAX SCHOEN

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In a previous paper[1] the writer made an attempt to indicate that the battle of the instincts among psychologists is due principally, if not altogether, to the failure to treat native behavior comparatively, as an evolution, and therefore as a variable factor. The most frequent use of 'instinct,' however, implies that it is an invariable state of being, true of all forms of life. There is 'instinct' all along the line, from insect to man, but not 'instincts.' We may speak of the 'instincts' of ammophila, but not of the 'instincts' of the human infant, excepting in a very limited sense. Once this point of view is admitted, the grounds for the quarrel about 'are there any instincts,' and for such antagonistic points of view as those represented by McDougall and Watson, vanish into deserved oblivion.

In this discussion the conclusions drawn on the nature of instinct are applied to another controversial problem in psychology, namely the relationship between instinct and intelligence.

"Man," says J. Arthur Thomson, "has his reflexes and a little instinctive behavior; most of his activity is either intelligent, or was originally intelligent, but has become habitual; the point is that, if occasion arise, man may instantaneously pass from a lower level to that of rational conduct."[2] And man is able to do this in the main because he is least hedged in and limited by his native instinctive equipment. Man is the most intelligent of organisms because he can meet most adequately and most readily the largest variety of most complex situations. In other words, he is most intelligent because he is most educable, his greater

[1] PSYCHOL. REV., 1927, 34, 120–125.

[2] 'The System of Animate Nature', N. Y., 1920, p. 515.

educability being due to the plastic state of his native behavior. Intelligence thus means degree of variability of native behavior. Where the original behavior is least modifiable, intelligence is least present, and where it is most variable intelligence functions in its highest form. And since all behavior, including even the simplest reflexes, is subject in some degree to the influence of education, intelligence of some kind functions throughout the entire scale of life until we reach its maximum degree in man. Intelligence does not rule out instinct, nor does instinct exclude intelligence, but both are two phases of one and the same process, namely, adjustment to a situation. The evolution of intelligence is concomitant and coëxtensive with the evolution of instinct, in that the higher the form of instinctive behavior, the greater is the intelligence. To put it differently, native behavior is instinctive behavior, while acquired behavior is intelligent behavior. But that which is acquired arises out of that which is native. Hence, intelligence is as native as is instinct, since intelligence is conditioned by instinct. That is, that which is acquired and that which is native are basically one and the same, as the acorn and the oak are one.

When we examine the relationship that exists between mind and behavior, we reach a similar conclusion as to the identity of instinct and intelligence. The nervous system is the machinery of adjustment. An adjustment involves the functioning of two factors, a nervous and a muscular activity. The nervous activity consists of impulses of various degrees of complexity, depending on the complexity of the central nervous system: the more complex the nervous system, the more numerous and involved are the impulses. And it is the nature of the impulse that determines the type of the muscular activity. Simple impulses lead to simple behavior, and complex impulses result in complex behavior. Thus, when an impulse coming from any sense organ reaches the spinal cord, it may either travel directly and immediately to a muscle via a motor nerve, or it may be relayed to some higher nervous center. Organisms with a rudimentary nervous system, those lacking higher nervous centers, or those in whom the higher

centers exist in but an elementary form, are capable of but simple behavior that approaches the state of reflexes. The responses of such organisms to a situation are trigger-like, immediate and mechanical, which means least educable, or least intelligent, since reflexes are the least educable elements of human behavior. Animals in whom the central nervous system is more highly evolved, or who possess higher nervous centers, manifest a more complex form of behavior, and their responses are more deliberate, more educable, or more intelligent. It seems, then, that intelligence and nervous process are identical, and likewise intelligence and deliberate or delayed behavior are identical. Intelligence is then definable as delayed behavior, and delayed behavior is educable behavior. The longer that behavior is delayed, the more intelligent it is, which means in turn that the number of nervous processes involved is greater before the final adjustment to the situation takes place. If instinct is native behavior, then it is clear that the end result of delayed or intelligent behavior is as instinctive, for higher forms of life, as is immediate behavior for lower forms of life, and there is no ground for drawing a distinction between an instinctive act and an acquired or intelligent act. We may speak rightly of degrees of intelligent behavior, or of degrees of instinctive behavior, since all behavior is intelligent in that it is more or less educable, and since all behavior is instinctive in that the native element determines its educability. In man instinct makes possible the most intelligent behavior, in the insect the least intelligent behavior. In man, certainly, no act can be said to be either instinctive or intelligent, but is as much instinctive as it is intelligent, since it is the state of his instinctive behavior that constitutes his intelligence.

The common practice of ascribing a dual nature to man, the one human and the other animal, owes its origin and persistence to the false juxtaposition of instinct and intelligence discussed above. On the basis of this mistaken notion repeated attempts have been made to explain, and often to justify, the existence of many social and individual evils, while numerous plans have been proposed whereby the in-

stinctive 'beast in man,' constituting his lower nature, might be defeated by the exercise of his higher nature, or his intelligence. Man, it is said, is by nature pugnacious, grasping, envious, jealous, and at the same time also sympathetic, gregarious and loving. Hence, his makeup is not only dual, but mutually antagonistic and contradictory. The function of intelligence must therefore be that of serving as a moral guardian and censor over the instinctive brute, to refine it and to keep it within proper and respectful bounds. Hence, the horde of maxims, admonitions, and preachments for the control of what is called human nature, the sum and substance of which is summarized in the notion that whereas instinct can not be eradicated it can at least be modified and controlled. This doctrine is the psychological counterpart of the theological tenet of original sin, and, like the latter, has been utilized to justify wars, industrial strife and social and political aggrandizement.

But a preachment is never against an instinct, something that an individual does natively, but always against some individual or social habit. Human beings love nothing by instinct and hate nothing by instinct, but acquire their likes and dislikes in a subtle but nevertheless detectable manner. A child can be taught to hate or to love any person or object, and it can be turned either into a pugnacious or peaceful creature, depending on how and where it is reared. Mother love is no more an instinct than is love for one's country or family, a painting or a house. The movement for the abolition of war is not an attempt to eliminate or suppress a pugnacity instinct by intelligence, but to change vicious and destructive social habits into constructive ones. This changing conception of the relationship between instinct and intelligence not only shows up man in a more hopeful light, but also reveals human nature in its true state, namely, that man is a creature of habits, a creature of intelligence, and that his nature is whatever it is made to be by education. The evolution of intelligence and the evolution of instinct constitute a single process, instinct being but another name for intelligence, and intelligence another name for instinct. The

highest form of instinct is the highest form of intelligence, and the lowest form of intelligence is the lowest form of instinct. Instinct and intelligence are inseparable. Whatever an organism does instinctively is a sign of its intelligence, and whatever it does by intelligence is an indication of its instinctive state. There is not a single act of behavior that man performs that is either exclusively intelligent or exclusively instinctive, but it is always instinctively intelligent.

Intelligence, then, means the degree of the variability or educability of native behavior. Consequently, just as instinct and intelligence are one, so are intelligence and education. A man displays his intelligence by what he can do, and what he can do is the result of his education. Man is the most intelligent of animals because he is the most educable, and there is no other indication or measure of his intelligence than his education, or what he can actually do. An infant at birth has no more intelligence than a bird, although we know by experience that the child will develop more intelligence than will the bird, and we therefore infer that the child has greater intellectual *capacity* than the bird. The notion of capacity is but an inference from actual accomplishment, but remove accomplishment and you know nothing about capacity. We know of no capacity, as such; all we know of is accomplishment. When we say that accomplishment is in proportion to capacity, we are defining the known in terms of the unknown, certainly a reversal of scientific procedure. It may be objected, however, that there must be such a thing as capacity, since for one and the same person accomplishment will vary with varied training, which means that one type of training brings out one's capacity, and another type of training does not. But this simply means that accomplishment depends on the conditions in which the person finds himself, that one set of conditions will bring out one type of accomplishment, another set of conditions a different type of accomplishment, which is only stating that man is a most variable, or educable creature. It may be argued further that often one's accomplishment does not measure up to one's capacity. But this again is only stating in ambiguous terms

what is very evident, namely, that experience teaches that accomplishments vary with conditions.

Does the above contention deny the existence of native individual variation? Not at all. Human beings vary fundamentally in muscular and organic structure and texture, and hence in the functions and powers of these structures. But this difference in structure only means a difference in susceptibility to different kinds of environment, condition, or training. One kind of temperament, for instance, will be more responsive to a certain kind of influence than will another kind of temperament. The objection to the notion of capacity is its flavor of fatalism or predeterminism, while we know by experience that so long as he is alive, man is modifiable,—only that, with the advance of years, the structure becomes more and more set and less and less variable. But man's power for modification is never completely exhausted, and hence he has no capacity as such, but only possibilities for accomplishment or educability.

To summarize, we find that man is primarily and essentially a creature of education. The education of the human organism begins at birth, and continues throughout life. However, human beings differ in intelligence, since they differ in structure. But intelligence is not structure, but what happens to the structure through education. The structure influences the kind of effect produced by a certain education, and it is for this reason that the same environment will produce different effects upon different individuals. But this does not mean that structure limits education as a whole, but rather the kind of effect and how much of an effect a certain kind of education will produce upon him within a certain given time. It is, therefore, education that counts, and not capacity. Man's sole capacity is to be influenced differently by education, and his intelligence is to be ever subject to education.

[MS. received October 24, 1927.]

DISCUSSION

A DEMONSTRATION OF SUGGESTION AND INVOLUNTARY IMITATION FOR THE CLASSROOM [1]

This demonstration has been used by the writer for several years in classes in elementary psychology, social psychology, and abnormal psychology, in connection with discussions of ideomotor action, suggestion, imitation, and closely related topics. The sources of the demonstration are obviously experiments used by the hypnotists (although hypnosis is not considered in what follows), with ideas from such discussions of imitation as are provided in Allport's and in Smith and Guthrie's texts.[2]

The demonstration, which may well be subject to modification, involves two parts, or three if a preliminary step is taken. This preliminary step consists simply in showing the ideomotor process. In the writer's experience the *pendule explorateur*, which can be made in a moment from a very light stick like a pen staff, a thread, and a small weight such as a button, is most convenient here. A naïve member of the class is asked to come up to the front of the room and to hold the *pendule* with the weight hanging, like bait from a fishing rod, over the center of a large plus sign which lies flat on the table before him. Then, told to "think of the horizontal line," "now think of the vertical line," the weight is seen to swing correspondingly—except for some subjects whose arm muscles do not seem to be implicated in such 'thinking.' Or the subject may be told to think of sliding a ring on a wire back and forth, back and forth, along the horizontal line, and after a moment, up and down

[1] Read at the meeting of the American Psychological Association, Columbus, Ohio, Dec. 29, 1927.

[2] Allport, F. H., 'Social Psychology,' 1924, pp. 178–186, 240; and Smith, S., and Guthrie, E. R., 'General Psychology,' 1923, pp. 131–133. The essential explanation of imitation given by these authors, and still commonly neglected in current texts, was put forward as early as 1880, by Rudolf Heidenhain. *Cf.* Gurney's statement of Heidenhain's view that "clearly no association can well be closer or more constant than that between the sight and sound of a movement or word and the act of producing that movement or word," discussed by Gurney in *Proc. Soc. Psych. Res.*, 1884, **2**, p. 279.

similarly on the vertical line.[3] This preliminary step, or its equivalent, may of course come any time before taking up suggestion and imitation as such. The parts of the demonstration proper, however, should come within a single class hour, for reasons which will be apparent.

First, two students are asked to leave the room and to remain well outside the range of hearing until called for. Then all the remaining members of the class, who should be seated in a close group as near the front of the room as possible, are instructed to clear off the writing boards of their chairs, to close their eyes, and to raise their right arms up to the vertical position. "Now," the instructor says, "I want you to imagine, with the utmost vividness, exactly how it would feel to bring your arm down upon your writing table with a *bang* at the very instant you hear a sudden, loud noise. Just think of your arm coming down automatically, and feel how your hand strikes the board, when you hear the sudden loud noise. . . . Now as I see our time is getting a little short, I am going to work in another experiment, very quickly. As you sit with your eyes closed and arms up, I want you to try to spell 'University' backwards, quietly, to yourselves, just as fast as you can. Spell 'University,' backwards, as fast as you can." As soon as the students have entered upon this new complication, there is produced a sudden, loud noise, such as a sharp clap of the hands; and this part of the demonstration is accomplished.

The instructor hastens to explain to the astonished students that the involuntary descent of hands was not owing to hypnosis, any more than are common occurrences of every-day life, as will be illustrated presently. The hands surprised their owners by coming down, only because the owners had forgotten for the moment the close connection they had themselves just established, though 'imaginatively,' between a noise and this response. "As a man thinketh in his heart, so is he." The experiment was performed on the large group to give as many as possible a chance to experience the phenomenon.

As, however, a considerable number of (doubting and rationalizing) students may have brought their hands down through mere imitation of others, rather than through the ideational connection

[3] The latter suggestion is communicated by Professor W. R. Wells. For further material on the *pendule* (or Chevreul's pendulum, as it is often called), *cf.* Barrett, W. F., 'Psychical Research,' 1911, p. 26, *circa*; and Baudouin, C., 'Suggestion and Autosuggestion,' 1921, pp. 248*ff*.

mentioned, this part of the experiment should be repeated upon two uninitiated subjects, without the example of others. The two students outside are now called back into the room and seated where all can see them. With the class merely observing, the two subjects are given the same instructions that had been given to the group the other time, except that the part about spelling backwards is modified as follows: " . . . Now as I see our time is getting short, I am going to work in another experiment, this one upon all of the class, including these two subjects who have their arms raised and their eyes closed. I want everybody, including these two subjects, to try to spell 'University' backwards (etc.)." The sudden sound is given as before, and usually with the expected result. Again (for the benefit of these two, at least) it is explained briefly that the response was not mysterious, but represents a not infrequent sort of occurrence in daily life, of which illustration will be given.

But it remains to demonstrate (as the students are *not* advised) imitation as such. For this, the two students are sent out of the room again, this time with two of those who brought their arms down with the class, previously. In the absence of these four, the instructor explains that he is going to tell the four and all the rest of the class to imagine bringing their "arms down with a bang" when they see a sudden, bright light. Actually, as he informs the class now, there will be no sudden light; there will be only a motion of his finger which all, except the four subjects, will see if they watch for it as a signal to (this time voluntarily) bring their hands down all at once. "Like this: One, two, bang. I'll do it again, so everybody will be ready." The signal is repeated silently; the quite objective (non-giggling) character of the experiment is mentioned; arrangements are made to have the four students sit facing the class; and these four are called in.

The instructor stands behind the four subjects, facing the class. "I am going to ask all of the class to try this experiment," he says. "This time I want you all to raise your right arms as you did the first time, but with your eyes open, and imagine your arms coming down with a bang the instant you see a sudden, bright light. Think just how it would be to have your arms come down automatically when you see a sudden, bright light." Then he gives the signal; and the arms of several or all of the four subjects are observed to come down with the rest.

(A simpler form of this demonstration is to send no students out until after the first part, when two whose arms came down with the

group then are asked to withdraw; performing the imitation part with these two only, instead of with four.)

With the demonstration completed, the instructor has opportunity to discuss several topics. The way fatigue predisposed to the descent of the waiting arms might be mentioned. Ideomotor action has already been touched upon. The relation of phantasy to action, and with it for that matter the relation of lapsed intent to action, has been suggested, and illustrations from daily life come to mind. The present writer remembers, for example, an incident that occurred in his boyhood. With several others he was walking home from a picnic with a large basket on his arm. A passing automobile reminded him that his father was due to come by in a similar car at any moment. "Oh," he remarked to the group, "when my father comes by, I'll toss this basket to him and he can take it home in the car." The conversation was resumed, and no more was thought of the basket, until something reminded the boy that his father had remarked that the ride in the car was to be only as far as the edge of town. "Oh, that's right," the boy thought to himself. "I won't throw the basket into the car after all, because then my father would have to carry it all the way across town." Again the basket-bearer's attention turned to the conversation in the group. Within a few moments a klaxon sounded, the father's face appeared in a passing car, instantly the boy leaped forward and tossed the basket to his father, the car went over the brow of the hill, and the undesirability of the action came to mind.

Perhaps a Freudian interpretation should be allowed for in the explanation of this incident. Certainly, however, the contrast in effect between the overtness of the intention to get rid of the basket, and the tacitness of the intention to keep it, should not be overlooked. Primacy would be another factor. And—in more obvious relation to the class demonstration—it seems quite clear that an important reason the action first considered was carried out in such a mechanical manner was that it was not *integratively* inhibited. That is, the opposed course of action, the intention *not* to have the basket go by automobile, was (somewhere) 'in mind,' had been acquired as a readiness to act in a certain way, it is true; but this particular readiness had not been closely enough linked with the conditions under which the *opposite* readiness had been established, so as to effectively inhibit the opposite attitude. The result was that the latter lay in readiness to be touched off by its appropriate stimulus: the basket went into the car. In the case of the hands

coming down while the attention was switched to something else, this lack of closely integrated inhibition is even clearer, as no idea to the definite contrary had been suggested at all. (Various educational implications arise here.)

Yet contrary ideas may have been present in some students, as will usually appear upon questioning those whose hands failed to come down with the others. Indeed, such questioning will often bring out a variety of interfering processes.

The 'conditioned reflex' character of imitation is especially indicated in the fact that (at least two of) the students who brought their hands down through involuntary imitation had only a few moments before had the experience of bringing their hands down when they heard the noise with the others bringing down their hands at the same time.

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[MS. received November 19, 1927.]

THE FLOATING–FINGER ILLUSION

Illusions have interested students of psychology since the time of Aristotle. In the belief that they still have value as teaching devices I herewith describe an illusion which I believe to have something of novelty about it; not that it contains any new prin-

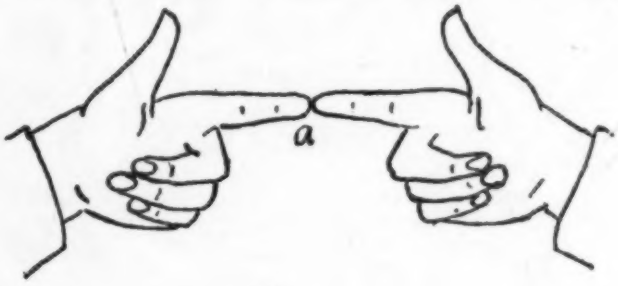

FIG. 1.

ciple, but rather that it is a novel variation of an old one. Involving double imagery, it is somewhat akin to the old illusion based on binocular suppression in which an individual with the aid of a paper tube may apparently look through a hole in his hand—a rather startling effect. Anyone with binocular vision can easily get the illusion described in this article; it will give him an effect no less startling.

The individual brings his two hands before his eyes, palms facing him, with the index fingers touching end to end as indicated in Fig. 1. With his hands in this position some twenty to thirty centimeters in front of the eyes, let him now fixate a more distant point in such a way that the line of vision passes directly over point 'a.' He now seems to be holding an elongated oval of 'finger-flesh' between the two index fingers; both *visually* and *tactually*, he seems to be supporting this phantom finger (Fig. 2). Now to get the float-

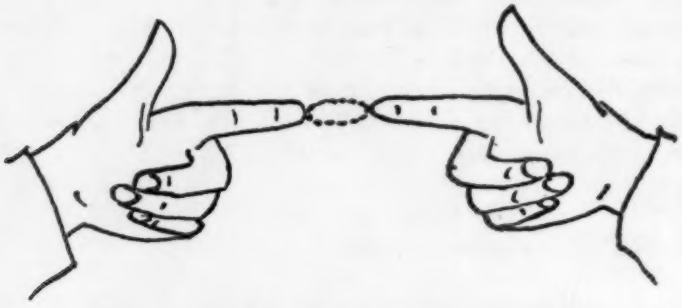

FIG. 2.

ing-finger effect, all the individual needs to do is to draw his fingers apart slightly—about one centimeter. He now experiences the strange and weird illusion of seeing the phantom finger floating in air, as shown by Fig. 3. It no longer has any connection with the

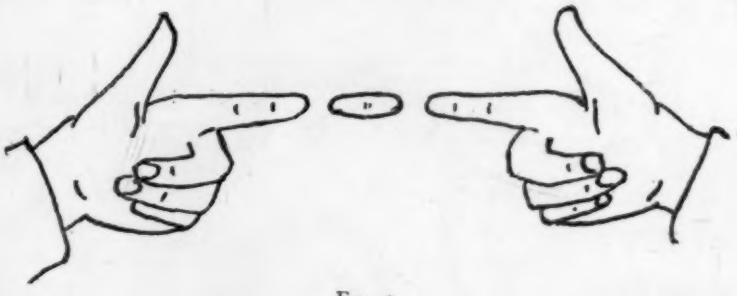

FIG. 3.

body, either *visually* or *tactually*. It gives the impression of a disconnected finger suspended in air without support of any kind; and yet, though the individual has no visible or tangible contact with it, he seems to mysteriously control it, for as his fingers move, so it moves. It gives one a sort of uncanny thrill to see this piece of flesh

which is so evidently a part of himself, and yet which is apparently so completely severed from his body.

I stumbled upon the above illusion during a course in 'space-perception'; I have since used it a good many times in class discussions of the subject and invariably it catches the interest of the class. Most students get it so easily and so distinctly that it seems a truly objective experience; not infrequently have I noted students blinking their eyes and shaking their heads vigorously as if to pull themselves back to reality.

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